SCIENCE ABSTRACTS.

Section A.—PHYSICS.

SEPTEMBER 1919.

GENERAL PHYSICS.

1131. *Resistance Vacuum-Gauge.* **M. Sô.** (Phys.-Math. Soc. Japan, Proc. 1. pp. 152–163, June, 1919.)—Describes the construction and testing of a resistance manometer similar to that of Hale [Abs. 256 (1912)]. With the instrument pressures down to 0·00001 mm. of mercury can be measured. The effects upon the sensibility of the manometer caused by different heating currents and by different surrounding temperatures have been studied, and it was found that within the range of filament temperature from 120° to 285° C. the sensibility was constant, the sensibility at 49° C. being about 55 % of that in the above range. The effect of the temperature of the surroundings is considerable, the sensibility varying from $1·38 \times 10^{-8}$ at 0° C. to $1·03 \times 10^{-8}$ at 15° and $0·756 \times 10^{-8}$ at 30°. Using the manometer to measure pressures it was verified experimentally that at low pressures, from 1×10^{-6} to 2×10^{-3} mm. of mercury, the thermal conductivity of air is proportional to its pressure. A. W.

1132. *A Glass Manometer with Elastic Walls.* **G. Baume** and **M. Robert.** (Comptes Rendus, 168. pp. 1199–1201, June 16, 1919.)—For measuring the pressure of fluids which attack mercury, manometers made of glass, silica, or resistant metal are used having thin walls which function according to the Bourdon principle (*e.g.*, Ladenburg, Johnson, Dunoyer, Bodenstein, Scheffer and Treub, Pellaton, etc.). Such a manometer has been designed by the present authors in the course of a research on the higher oxides of nitrogen, based on experiments by Ramsay and Young. The instrument used consisted of a thin glass vessel of about 6 cm.^{3} capacity which was filled with mercury and surrounded by the envelope wherein existed the pressure to be determined. The volume variations were measured by the displacement of the mercury in a capillary tube of about 0·4 mm. diam. attached to the above mercury vessel. A large diagram of the apparatus is given in the paper. The sensitiveness of this manometer has been found comparable with that of a good mercury manometer throughout an extended pressure-range. The deformations of the apparatus when vertical are shown to be proportional to small pressure variations at constant temperature. The variation in sensitiveness is next found for different inclinations. Calculation and experiment are shown to give almost identical values. Data for the vapour pressures of nitrogen peroxide conclude the paper. These are found to be in excellent agreement with the data by other methods. H. H. Ho.

1133. *Instrument for the Determination of Accelerations.* **[Prince] B. Galitzin.** (Roy. Soc., Proc. 95. pp. 492–507, July 15, 1919.)—An apparatus is described for the determination of accelerations without involving complications due to the motion of the apparatus itself. A pointer is attached to a heavy suspension so arranged that it exerts a pressure on a plate. If the apparatus is accelerated in the plane of the pointer, the pressure on the plate is either increased or diminished according to the sense of the motion. The change of pressure is proportional to the acceleration, but cannot be measured mechanically since this would involve the acceleration of the moving parts of the measuring device. The phenomena of piezo-electricity can, however, be used. A plate of tourmaline between two metallic sheets is used, and the charge measured by means of a Lutz-Edelmann string electrometer. The charge is proportional to the pressure. The apparatus give directly, without any appreciable retarding effect, the instantaneous value of the acceleration, however arbitrary the type of motion may be. It does not introduce any oscillations of its own. It has a very small inertia, and does not manifest fatigue. The sensitiveness may be regulated as desired. Since the sensitiveness grows rapidly with the decrease of the period, it is particularly convenient for short oscillations. The constant of the instrument may be determined without any difficulty, and the acceleration can then be obtained direct in c.g.s. units. The apparatus can be constructed in compact form and made portable.

To determine three components three sets are of course required. W. A. R.

1134. *Recent Progress in the Metric System.* **C. E. Guillaume.** (Bureau Int. Poids et Mes. Mem. 16. [116 pp.] 1917.)—This is a Report drawn up for the General Conference on Weights and Measures, held in Paris in October, 1913. It gives a lengthy account of the changes suggested in recent times in the metric system of weights and measures in all countries. A few notes on striking features are: (1) The behaviour as to thermal expansibility, thermal hysteresis, and secular change, in length scales made of natural quartz, vitreous silica, commercial nickel, 36% nickel-steel (in bar), 42% nickel steel. The last-named has several good qualities. (2) The periodic determination of the prototype kilogrammes. Comparison is shown between results obtained on sixteen standards from 1899 to 1904; the change in mass attributed being in some cases as much as 0·03 mgm.—in others no more than 0·001—0·002 mgm. (3) The standard wave-lengths used in metrology, which used to be hot cadmium or mercury vapour, are now those produced by the low-temperature vacuum discharge through krypton or neon. This is due in great part to the work of Buisson and Fabry. (4) The corrections which have to be applied to the constant-pressure or constant-volume hydrogen or nitrogen thermometer, as derived from the work of Rose-Innes Berthelot, Callendar, Onnes, and Buckingham are tabulated for a range of temperature from —250° C. to 1000°C. (5) A list is given of modern values of standard melting-points and boiling-points. (6) The legislation on c.g.s. and derived units in a score or more countries is given. Notable among these is a full list of units as defined by the Argentine Republic. This includes mechanical and electric units. (7) Special attention is devoted to specification of the unit of mass, the carat for precious stones. It is suggested that the metric carat be 200 mgm. The value of the carat in the United Kingdom

is about 205·3 mgm. Of 44 countries specified the United Kingdom shows the least appreciation, as indicated by legislation, for the metric system.
P. E. S.

1135. *Test of Measuring-Gauge Blocks.* (Engineering, 108. p. 22, July 4, 1919.)—The Pratt & Whitney Co., Hertford, U.S.A., are manufacturing extremely accurate gauge blocks by a process due to W. E. Hoke. The blocks are "glass-hard, special steel" blocks, about 1 in. square with a ¼-in. hole in the centre so that they can be conveniently stacked on a ¼-in. rod. It is claimed that the thickness is accurate to three-millionths of an inch; most of them, it is said, vary by less than one-millionth of an inch in flatness and parallelism.

The method of determining the errors is a simple optical one. An optically-worked glass disc is rested on top of a block and the interference bands formed between glass and steel are observed. The light used is generally the monochromatic light from a mercury-vapour lamp. To determine the actual thickness of a block it is placed by the side of a standard block of known thickness. This pair rests on an optically true glass plate and another optically true glass is placed over them. If both are exactly equal in thickness the interference bands formed will run continuously across the junction of the two blocks. Want of continuity shows difference in thickness. The same method is used to test the very high-class surface plates made by the same company. P. E. S.

1136. *Formal Solution of Equations for Material Stresses.* **R. F. Gwyther.** (Phil. Mag. 38. pp. 235–240, Aug., 1919.)—Obtains the formal solutions in Cartesian coordinates of the stress equations found from the theory of material stresses previously described [see Abs. 819 (1918)]. The solutions in the cylindrical polar and spherical polar systems are long and complex, and the former are treated for the case when the points in the body are sufficiently distant from the polar axis. J. W. T. W.

1137. *Atomic Heat, Volume-Elasticity, and proper Frequency in Monatomic Metals.* **A. L. Bernoulli.** (Helvet. Chim. Acta, 1. pp. 278–288, Nov. 1, 1918.)—According to Madelung [Abs. 883 (1910)] and Sutherland there is a quantitative relation between the elastic constants (the elastic cubic compressibility) and the frequency of the infra-red proper molecular vibrations, assuming that the solid molecules are set into characteristic vibration under the action of distant repulsive forces. According to Einstein and Debye the work of compression would only increase the kinetic energy of rotation without affecting the repulsive molecular action. The latter assumption, the author shows from an examination of the atomic heat data of Nernst and Koref and K. Onnes and of the compressibility determinations of Grüneisen, brings the figures into better agreement for perfectly elastic solids. He also shows that the atomic heat may be calculated from a single compressibility determination at any (even low) temperature, and that the divergence from the rule of Dulong-Petit may similarly be deduced for copper, lead, and aluminium. H. B.

1138. *The Ductility of Metals and the Periodic System.* **G. Tammann.** (Gesell. Wiss. Göttingen, Nachr. pp. 247–254, June 9, 1917. Chem. Zentralbl. i. pp. 509–510, 1918.)—According to Lothar Meyer ductile metals lie near the maxima and minima of the atomic volume curve. The author considers that high ductility (the capability of being drawn into wire) requires the formation of a large number of slip-planes in the direction of the extension with a small expenditure of force. The ductility does not depend upon any particular space-lattice, but on the existence in the lattice of only one kind of atoms between which no valencies are active. When the valencies manifest themselves by the formation of binary components, the formation of slip-bands and the ductility are suppressed. Elements capable of existing in various crystalline modifications are ductile. In the periodic system the typical crystalline forms show a certain symmetry which is disturbed, however, by the intervention of the non-metallic elements of the carbon group. H. B.

1139. *Researches on Aluminium. I. Observations on the Specific Resistance, Temperature Coefficient of Resistance, Thermal Expansion and Tensile Strength.* **W. Jaeger** and **K. Scheel.** II. *Significance of the Temperature Coefficient of Resistance with regard to Structure and Chemical Purity of Aluminium.* **L. Holborn.** (Elekt. Zeits. 40. pp. 150–152, April 3, 1919. From the Physikal.-Techn. Reichsanstalt.)—Experiments have been made on samples of Al containing respectively 0·1 %, 0·4 %, 1·2 %, and 1·6 % of impurities, chiefly iron and silicon. The thermal expansion was found to be practically the same for all samples, and the results can be summed up by the formula $l_t = l_0[1 + (22{\cdot}9t + 0{\cdot}009t^2)10^{-6}]$.

Within the limits employed, impurities have little effect on strength, the 6-mm. wires having a tensile strength of 13 kg./mm.^{2} and the 3-mm. wire a strength of 17 kg./mm.^{2}.

The electrical resistance of a metal is affected not only by composition but also by structure. In determining the influence of impurities, therefore, it is essential to make sure that the samples under test are similar in structure, and in the case of wires this is effected by annealing the samples to be compared at the same temperature. On annealing hard-drawn material at gradually increasing temperatures the resistance at first decreases to a minimum and then rises again to a value higher than the original value. At the same time the temperature coefficient rises to a maximum and then falls again. In the samples of Al under test, the resistivity rises, and the temperature coefficient falls, as the content of impurities increases. The temperature coefficient has a max. value in the samples of wire annealed at 250° C., which is the best temperature for annealing since it produces the lowest resistance without seriously affecting the strength. Micrographic examination indicates that 250° C. is the temperature at which recrystallisation begins. Comparing the temperature coefficients of the samples between 0 and 100° C. it would appear that the coefficient of resistance does not increase regularly with the degree of purity. From 1·6 % to 0·4 % there is a definite though not regular increase, but the 0·1 % sample shows the same value as the least pure sample. Experiments with still purer Al are in progress. F. C. A. H. L.

1140. *Moduli of Elasticity and Rigidity of Nickel Steels.* **K. Honda.** (Tôhoku Univ., Sci. Reports, 8. pp. 59–60, April, 1919. Twenty-seventh report of the Alloys Research Inst.)—The author has measured the moduli of elasticity (E) and rigidity (K) of some Ni steels studied in a previous paper [Abs. 1190 (1918)]. The specimens were all normalised by heating to 900° C. The curves showing the variation of the elastic constants are similar to those of the thermal and electrical conductivity–concentration curves. L. L.

1141. *Two-dimensional Motion of a Plane Lamina.* **S. Brodetsky.** (Roy. Soc., Proc. 95. p. 516–532, July 15, 1919.)—Obtains the equations of motion of a plane lamina moving in a resisting medium and shows that, by making certain simplifying assumptions, the form of the path can be ascertained by graphical methods. The curves obtained are given in the paper for (i) a narrow lamina with a large moment of inertia moving under the influence of the air resistance only, and (ii) a wider lamina, taking into account the resistance couple. The treatment is also given for cases involving applied forces additional to the air-resistance. Photographic records of the flight of an actual lamina are given in the paper. J. W. T. W.

1142. *Static Friction and Lubricating Properties of Certain Substances.* **W. B. Hardy** and **J. K. Hardy.** (Phil. Mag. 38. pp. 32–48, July, 1919.)—The experiments here described were undertaken with the object of clearing up the paradoxical results previously described by Rayleigh [Abs. 380 (1918)]. W. B. Hardy has shown that the variation of the surface energy at an interface between two fluids, and of a composite surface, is closely related to the chemical constitution of the substances concerned. The inference to be drawn is that the work done in forming the interface or the composite surface is done by chemical forces. In the theory of capillarity developed by Young and Laplace, cohesive forces are taken to be, like gravity, incapable of saturation, and unlike gravity only in being of very short range. If cohesive forces are chemical they are incapable of saturation, or of "neutralisation," and the film of matter on a composite surface may be said to reduce the surface energy by neutralising to a greater or less extent the forces at the surface of a solid or fluid. The function of a lubricant is to reduce the energy of the surface, and thereby to reduce the capacity for cohesion, and the resistance to slip when two composite surfaces are applied the one to the other. The function of a lubricant, therefore, is opposite to that of a flux. Evidence for the orientation of the molecules at an interface or on a composite surface, which is taken to be the source of static friction, is to be found in the fact that chemical substances whose molecules are readily polarisable, produce the greatest changes in surface energy, and that there is contact difference of potential between the film of a composite surface and the matter on which it lies. The theory of static friction which accords best with the facts, is that it is due to cohesion between the faces. When a lubricant is present we may consider the friction as operating at an imaginary surface situated in the lubricant, parallel to and midway between the solid faces. The experiments showed that cleaned faces cannot slide over one another. The forces of cohesion come into play and the surfaces seize. In the case of glass, once seized, the substance of the glass fractures before the seized surfaces will give. Very slight normal pressure is needed to cause seizing. An unweighted watch-glass cannot be moved on a plate even quite slowly without producing torn tracks, if both faces are really clean. It was found that certain fluids have no power of lowering the friction. The *inactive* fluids discovered were ethyl alcohol, ethyl ether, water, and ammonia (*fortiss.* sp. gr. 0·880). Glycerine is remarkable in that a film of the liquid has no effect, though flooding the surfaces with glycerine increased the facility for slipping nearly, if not quite, to the maximum. *Active* fluids differ amongst themselves, and some interesting results were obtained with the limited number of substances used. Evidence was obtained of the effect of chemical constitution in radically altering the frictional coefficient.

A. W.

1143. *Cohesion.* **H. Chatley.** (Phys. Soc., Proc. 31. pp. 91–93, April, 1919.)—In reply to H. S. Allen's remarks on his last paper [Abs. 899 (1918)], the author observes that Sutherland's hypothesis, which appears to be totally electrostatic, gives zero force at large distances, and so would not explain gravitation; also that, in the absence of real knowledge of molecular structure, approximate formulæ for partially equivalent molecular forces are useful. He therefore adheres, for the attraction, to the formula $t_2 = Gm^2/d^{2+n/k}$, where n is a little greater than 4. For the repulsion, he suggests $t_1 = RT/Nd_0 . 1/3(k-1)$, a formula based on the standard expression for the *virial*, or kinetic energy of a molecule, and allowing for the actual molecular interstice $(k-1)d_0$. From Bragg's results he supposes the crystal to be a kind of open framework with atoms in effective contact along various lines, which would accord with the great changes in molecular volume during chemical changes. Moreover, the high conductivity and small heat capacity at low temperatures and the minute expansions from absolute zero to fluidity, all seem to show atoms to be practically in contact at certain points.

G. W. DE T.

1144. *On the Theory of the Brownian Motion.* **L. S. Ornstein** and **H. C. Burger.** (K. Akad. Amsterdam, Proc. 21. 6 and 7. pp. 922–931, 1919.)—The object of the present communication is to show that in the new theory of the Brownian motion developed by van der Waals, Jr. [see Abs. 12 (1919)], various wrong assumptions have been made. Van der Waals starts from the equation of motion of a Brownian particle as given by the formula $\ddot{x} = \omega(t)$, where $\omega(t)$ is the force which the particle experiences from the molecules of the liquid and of magnitude dependent upon chance. To arrive at a theory of the Brownian motion, van der Waals assumed that $\dot{x}_0\omega(t)$, that is, the product of the velocity at the time zero and the force at the time t, is zero on an average over all particles, but this assumption of an average is now shown to lead to impossible consequences [see also Abs. 10 (1919)]. The theory of van der Waals also rests on the thesis that the magnitude

$$\omega(t)\int^{t} \omega(\vartheta)(t-\vartheta)d\vartheta$$ is essentially negative, if only t be not taken too small.

This is now shown to be incorrect, since the sign of the integral for larger values of t is proved to be quite arbitrary and dependent on the choice of $f(n)$ in the Fourier series representing $\omega(t)$. The improbable result is next proved that the average value of the velocity of a Brownian particle never reaches the equipartition value. Finally, in van der Waals' paper it is urged that Langevin's deduction of the formula $\overline{\Delta^2}$ contains an inner inconsistency. This is shown not to be the case, and that no contradiction exists.

H. H. Ho.

1145. *Spreading of Fluids on Glass.* **W. B. Hardy.** (Phil. Mag. 38. pp. 49–55, July, 1919.)—Two distinct processes are shown: (1) the spreading to form an invisible film, and (2) the spreading of a drop to form a layer. The first is distinguished as primary spreading, and the surface formed by it as a "primary composite surface"; the second, as secondary spreading which forms a "secondary composite surface." A primary surface is covered by a film of the order of I μ in thickness, whilst a secondary surface is covered by a layer from 50 to 500 μ in depth. From a drop of certain fluids primary spreading occurs; if the fluid in question is not rigorously pure secondary spreading follows, and certain fluids will not spread at all. Experiments with various substances are described which illustrate these statements. Thus, with a drop of pure acetic acid in the absence of moisture, primary spreading only occurs, but if any moisture is present it acts as an impurity and secondary spreading of the drop takes place. Tripropylamine behaves in the same way. Whether primary or secondary spreading does or does not occur on a fluid face, depends mainly on the relative value of the surface tensions, but on a clean solid face it must depend wholly upon the vapour tension. If vapour is given off from the drop it will condense to form a primary composite surface, and this being contractile may pull the drop itself out to form a secondary surface. The fact that B.P. "paraffin" and castor oil do not spread at all on clean glass is due to their low vapour-pressure, and is no evidence as to the tension of the glass–oil interface.

[See Abs. 1394 (1918).] A. W.

1146. *Stratification of Liquid Films.* **J. Perrin.** (Ann. de Phys. [ix.] 10. pp. 160–184, Sept.–Oct., 1918.)—Studying horizontal soap-films under the microscope, the author observes, like Johonnott (1906), five orders of black spots. The first order represents the thinnest, blackest and most stable film on which tiny spherules, probably of water, describe Brownian movements so intense that the spherules cannot be in contact with the film, but must be floating above it. When dilute solutions of fluorescent compounds [see Abs. 1214 (1919)] are added to the soap solutions, the number of distinct spots becomes much greater: 18 black, grey and white spots, as many yellow and red, and 1 violet have been counted. Each spot appears in its own colour, and is bounded by circular arcs. The phenomena suggest a regular stratification in parallel layers; the Brownian movements decrease with increasing thickness and cease, in the case of uranin, when the thickness exceeds 0·2 μ. When the illumination is so arranged that it affects only half a circular spot, the dark half is found to be non-stratified, but the stratification spreads over into the dark half. Thus light and also rise of temperature favour the stratification. Stratification is also observed in aqueous resin emulsions (colophony) rendered alkaline by caustic potash, but free of soap. In monochromatic light, 40 spots varying in thickness up to 215 $\mu\mu$ have been observed. As these thicknesses seem to be multiples of 5 $\mu\mu$, it is suggested that the layers are of the nature of liquid crystals. The low surface tension of the superficial film of soap bubbles further indicates that, in the surface, the sodium oleate is hydrolysed into oleic acid, and that the interior is comparatively richer in soda. The author proves this in conjunction with Miss Delmon, by blowing air through soap solution, and by making the finest foam produced escape over the edge of the vessel; the foam thus collected is oily and acid, and quantitative experiments show that this superficial acid film has a thickness of about 2 $\mu\mu$, and would hence represent a layer of a depth of two molecules. H. B.

1147. *Large Liquid Drops and Gas-bubbles and their Use for Measurements of Surface Tension.* **J. E. Verschaffelt.** (K. Akad. Amsterdam, Proc. 21. 6 and 7. pp. 836–849, 1919.)—Highly analytical treatment of the meridional section of the capillary surface in question. E. H. B.

1148. *Nature of Liquid Surface.* **H. R. Proctor.** (Soc. of Leather Trades' Chemists, J. 3. No. 4. Chem. News, 118. pp. 292–294, June 20, 1919.)—An elementary discussion intended to disabuse students of widespread misconceptions. E. H. B.

1149. *On the Flow of Petrol Vapour.* **J. Rey.** (Comptes Rendus, 168. pp. 1092–1095, June 2, 1919.)—The author has given formulæ in a previous paper [Abs. 764 (1919)] for calculating the speed of flow of petrol vapour. Rateau has since remarked that these formulæ approximate to those which he has found for the flow of gas under high pressure, but that they are less exact. The author now gives the considerations which led to the deduction of his formulæ and discusses their deviation from the more rigid expressions given by Rateau. Illustrative numerical data are given. H. H. Ho.

1150. *Rate of Capillary Ascension of Liquids.* **R. Lucas.** (Kolloid. Zeit. 23. pp. 15–22, July, 1918.)—Capillary analysis is based upon the different rates of ascension of different solutions in unsized filter paper. For simple fluids (not solutions) the rates are in fair accord with Wo. Ostwald's formula $h^{1/m} = kt$, where h is the height to which the liquid rises, k a constant of unknown significance, and m has approximately the value 0·5. The author finds the rule to hold, with 3 grades of filter paper, for aniline, glycerol, nitrobenzene, carbon disulphide, etc.; his value for m is a little smaller than 0·5, but does not fluctuate so much as Goppelsroeder asserted. On the other hand, the formula is merely empirical and does not give the maximum h. From Poiseuille the author hence deduces $h^2 = \omega r \cos d(t/2\eta)$, where ω is the surface tension, r the radius of the tube, and d the meniscus angle. Expressed in absolute units Ostwald's k would be given by : $k\eta/\omega = r \cos d(t/2) =$ a constant independent of the liquid and proportional to the diameter of the pores. The porosities of the three papers calculated from experiments with various liquids were in satisfactory agreement, about 1 : 4 : 12·5. Strictly speaking the author's h^2 holds only for incomplete ascension and not for glass capillaries (except of very small bore) in which the ascension is rapid, but small. The author adds that W. Ostwald himself has pointed out the priority of a similar formula of Cameron and Bell, 1905. H. B.

1151. *Axially-symmetrical Solutions of the Einstein Gravitational Equations.* **H. Weyl.** (Ann. d. Physik, 59. 2. pp. 185–188, June 20, 1919.)—This paper is the outcome of a criticism by Levi-Civita, during his investigations on the static Einstein gravitational field [see Abs. 384 (1919)], of the present author's work on gravitational theory [Abs. 605 (1918)]. Levi-Civita concluded that although Weyl's results were valid yet they were incomplete, and the present supplementary note shows that only more explicit definition is necessary.
H. H. Ho.

1152. *Relativity Theory.* **G. W. de Tunzelman.** (Science Progress, 13. pp. 475–482, Jan., and pp. 652–657, April, 1919.)—The origin of the relativity hypothesis, its development by Minkowski into a legitimate physical theory, or working model, the essential necessity of its expression in four-dimensional terms, and its reduction to precise formulation by Lorentz and Einstein are briefly discussed. The essential foundations of the mathematical formulation are shown to be capable of very simple expression in geometrical terms. Einstein's *Equivalence Principle,* that "*there is no distinction between a gravitational field and a field of acceleration*" is then discussed, and its theoretical and practical implications are considered. These lead the author to the conclusion that the Equivalence Principle appears to be untenable, and that the relativity theory itself should be regarded as a promising mathematical aid in elucidating and reconstructing defective portions of existing physical theory rather than as a possible alternative theory. It is pointed out that Einstein's formula for the anomaly in the motion of Mercury's perihelion is identical, to the order involved, with the one given by Gerber in 1898, and would, therefore, as the author has shown elsewhere ("Electrical Theory," pp. 601–616), account physically for the anomaly if gravitational potential be taken as velocity potential of the ether in any form of gravitation theory in which the electrons are regarded as sources or sinks of ether flow, provided gravity acts only on the electrodynamic mass of the electron nucleus, the inertia of which is then argued to be negligible relatively to the electromagnetic inertia. AUTHOR.

1153. *Possible Determinability of Characteristic Ether Constants.* **O. J. Lodge.** (Phil. Mag. 37. pp. 465–471, May, 1919.)—Present knowledge of these constants, μ and K, is that involved in the operational relation of Maxwell's theory, $\nabla^2 + \mu K d^2/dt^2 = 0$, when the operators are applied to any suitable electric vector. Observations suggest that K has some kind of elastic significance, while μ simulates the properties of inertia, suggesting the interpretation previously proposed by the author that $4\pi/K$ might be regarded as the transverse elasticity, or rigidity, of the ether, and $4\pi\mu$ as its density. If electric force be regarded as ether twist, then magnetic force will correspond to ether flow. Taking this as a working hypothesis, if the flow could be determined in a given field, the density would be derivable therefrom. A modification of Fizeau's experiment on the effect of moving water made by the author in 1892–3 [Abs. 959 (1907)] would have shown an ether-drift of 1 ft. per sec. Using a closed magnetic circuit wound with 1000 turns per cm. effective length, and cooling, say by liquid air, so that it can carry 1000 amps., an ether flow of 3 mm. per sec. could be detected—and such an experiment appears feasible. G. W. DE T.

1154. *Constitution and Structure of an Atom of Nitrogen.* **H. Collins.** (Chem. News, 119. pp. 29–30, July 18, 1919.)—This note refers to papers of a theoretical nature submitted to the Nobel Institute of Sweden in 1914, in which it was stated to be proved mathematically that an atom of nitrogen is constituted by the union of two atoms of hydrogen and one of carbon. Recent experimental results of Rutherford's [see Abs. 912 (1919)] confirm this theoretical deduction. Reference is also made to three other important "confirmations" of this kind, occurring in this mathematical paper submitted to the Nobel Institute. A. B. W.

1155. *The Disruption of the Nitrogen Atom.* **F. H. Loring.** (Chem. News, 118. pp. 311–312, June 27, 1919.)—The paper contains a short account of Part IV. of a series of papers recently published by E. Rutherford on "Collisions of α-particles with light atoms" [Abs. 912 (1919)]. The account of Rutherford's experiments is supplemented by the author's discussion. A. B. W.

1156. *Weather Forecasts.* **V. Bjerknes.** (Nobelinst. Meddel. 5. [Arrhenius Festskrift] (No. 3) pp. 1–15, 1919.)—The paper describes a method of forecasting weather which was adopted in Norway during the war, when information from Iceland, Faeroe, the British Isles, and France was unobtainable.

A very close network of reporting stations was established, consisting (1) of stations reporting pressure, temperature, wind and weather, arranged in two lines, one of which joins the heads of the fjords, and the other runs along the open coast; and (2) of stations reporting wind and weather only, which are well-distributed over the area, and are situated at lighthouses and lightships as far out from the coast as possible, as well as on the coast and inland. Wind direction was observed with great exactitude, and observations of the approach or break-up of large and high cloud sheets were also made. The observers, who were largely seafaring men or agriculturists, were encouraged to report signs of "drawing to rain," and these were of much use.

At the central office the observations were charted, and lines of air-flow were drawn in the manner advocated by Bjerknes in previous publications, and examined with a view to identifying lines of convergence of air. Of these lines Bjerknes recognises two to every fully developed cyclone, and he calls them the squall-line and the guiding-line (*Lenklinie*). The former passes S. and SSW. from the centre of the cyclone and separates a region with warm air to the east of it from a colder region to the west of it; the squall-line itself being the seat of squalls of wind with rain or hail, frequently accompanied by thunderstorms. This line is well known in meteorological practice and literature. The guiding-line is not so well known, for its existence was only recently pointed out by Bjerknes himself. It starts apparently from the centre of the cyclone in a direction tangential to the prolongation forwards of the path of the centre, then gradually bends towards ESE., SE. and SSE. It separates the warm region already referred to, which lies east of the squall-line and continues up to the guiding-line, from a cooler region to the east and north. This line is used considerably for these forecasts—its utility depends upon the property from which it received its name, *i.e.*, the fact that, at its northern end, it runs tangential to the future track of the cyclone, and therefore indicates the direction in which the cyclone will move. An accurate determination of the position of this line is therefore of great importance—it is for this reason that a close network of stations is necessary; in fact, it is said that the coarseness of the usual network is responsible for the failure hitherto to recognise this line as forming an essential part of the mechanism of a cyclone. The geographical distribution of rainfall is not obviously related to this line—rain falls long before the approach of the line, and continues for a time after it has passed.

In spite of the lack of observations from W. Europe, which added enormously to the difficulties of forecasting the extremely changeable weather of Norway, the results attained by the use of methods outlined above were remarkably good, for on the average more than 83 % of the forecasts were correct. The period to which they referred was, however, a short one. The observations were made at 8 a.m., and the forecasts subsequently based upon them referred to the rest of the day only. R. C.

1157. *Rainfall in England; the True Long-average as Deduced from Symmetry.* **A. A. Barnes.** (Roy. Meteorolog. Soc., J. 45. pp. 209–227; Disc., 227–232, July, 1919.)—Records from 38 rain gauges in England for the 62-year period 1856–1917 have been analysed with a view to determining what period of years gives the nearest approach to the true average. In order to determine the appropriateness of any value which is taken as the normal yearly fall at a given station a "Residual Mass Curve" is plotted. If R be the assumed normal and $R_1, R_2, \ldots R_n$ the actual yearly falls the "residual mass" at the end of *n* years is $\Sigma^n R_n - nR$. If R be chosen too large the curve will slope on the whole downward during the period and conversely, if R be too small, upward. Curves plotted in this way for Tring with different trial values of R show that 28·75 in. is the most appropriate value for normal for this station. When these "Residual Mass Curves" are plotted for representative stations they reveal the existence of symmetry in the curve on either side of the year 1886. Although the shapes of the curves differ for the north and south of England yet both show this symmetry about 1886. The symmetry indicates that any period of wet years before 1886 is balanced by a period of dry years at the corresponding time after 1886, and *vice versa*. From this it follows that to obtain a true long-period average for any station the period chosen should be centred at 1886. It is found that all the available periods of 34 years and upwards which are symmetrical with respect to 1886 give means which lie within 1 % of a value that may be regarded as the true long-period average. This is true for all the stations tested. H. R. Mill in 1903 used the 30-year period 1870–1899 as standard, and, judged by the present test, this was an exceedingly satisfactory choice. The British Rainfall Organisation 35-year standard 1875–1909 is also good, as inspection of the Residual Mass Curves indicates. A Residual Mass Curve for all England based on statistics from "British Rainfall" is appended to the paper. In the *discussion* **C. Salter** raised the question whether a true long-period average really existed or whether rainfall might not in reality be steadily increasing or decreasing. **H. E. Carter** had calculated mass curves for some Scottish and Irish stations. The results suggested that the point of symmetry did not fall in 1886 for the north of Ireland. **H. R. Mill** considered that the divergence of form of the curves found between the north and south of England might be regarded as fully proved. J. S. Di.

1158. *On the Errors which can result from an Incomplete Knowledge of Aerological Conditions.* **L. Dunoyer.** (Comptes Rendus, 168. pp. 1102–1105, June 2, 1919.)—On a long flight such as that across the Atlantic variations of wind may produce considerable deviations from the intended course unless they are correctly allowed for. To obtain numerical results two cases are considered: (1) that of a cross wind of constant direction the strength of which follows a sine-curve variation, the breadth of the current from one place of zero velocity to the next, or half period, being equal to the length of the flight; and (2) the case where the velocity remains constant but the direction of the wind varies uniformly along the course. For each of these cases the deviation, or lateral error, in making the point aimed at is calculated on the assumption that (*a*) no allowance is made for drift, and (*b*) that allowance is made throughout for a constant wind equal to that prevailing at the start. Taking a speed of flight of 150 km./hour and a max. wind velocity of 25 m./sec. the deviation at the end of the course may attain to 4/10ths of the length of the route if no correction for wind is made (case *a*) or to 8/10ths if the starting wind is corrected for throughout (case *b*). The errors may thus be very important. J. S. Di.

1159. *Atmospheric Conditions which Affect Health.* **L. Hill.** (Roy. Meteorolog. Soc., J. 45. pp. 189–207, July, 1919.)—The discomfort felt in crowded rooms is due to the low cooling and evaporating power of the air, not to its chemical impurities. To measure the cooling power from surfaces at body temperature the Kata-thermometer has been devised. The instrument is here described and the equations connecting its readings with the different meteorological elements (temperature, wind velocity, humidity, etc.) are set out. In an appendix the mean meteorological conditions are given for different stations and the cooling power is calculated. The cooling power in Madras in the shade and fully exposed to the wind during the worst months is found to be the same as that met with in shut-up rooms and factories in this country. Diagrams are given to prove how different the cooling power as shown by the Kata may be under different circumstances where ordinary thermometric readings show little difference. The hope is expressed that cooling power at body temperature may be measured as part of the regular procedure at meteorological stations. It is also hoped that vapour pressure rather than, or in addition to, relative humidity may be recorded, as being of more service for determining the cooling of damp surfaces at body temperature. J. S. Di.

1160. *Cases of Decrease of Wind Velocity with Increasing Height.* **A. Baldit.** (Comptes Rendus, 168. pp. 1211–1214, June 16, 1919.)—Wind velocity usually increases with increasing height, but there are cases in which it is found that velocity diminishes as height increases. Out of 650 pilot balloon ascents in France beyond 4000 m. height there were 250 cases in which the velocity decreased for a part at least of the 4000 m., and they are classified as follows: (1) Winds between N. and E. from 0 to 4000 m. (67 cases); (2) Winds between E. and S. from 0 to 4000 m. (24 cases); (3) Winds between E. and S. from 0 to 3000 m., then from S. to W. (13 cases).

The first class is the most important and most pronounced. Usually the velocity shows a maximum below 1000 m., then diminishes up to about 1600 m., and then increases again. Simultaneously wind direction backs towards the S.E. slope of an anticyclone; weather is fine and settled.

In the second class, wind velocity steadily diminishes from 1000 m. or less to 4000 m., wind direction remains steady throughout at about ESE. Frequently this type is associated with storms in SW. Europe.

In the third class velocity increases from ground level to 1000 m., then diminishes to 4000 m., the direction veering with increasing height. The occurrence of a case of this class is characteristic of the approach of a depression, and the receding towards the E. of an anticyclone which previously dominated the situation.

The gradients of pressure required at each height to account for the observed changes of wind, are found to be in agreement with those deduced from the surface gradient and the actual distribution of temperature both horizontally and vertically. R. C.

1161. *Nitrogen and other Compounds in Rain and Snow.* **J. E. Trieschmann.** (Chem. News, 119. p. 49, Aug. 1, 1919.)—The paper summarises the results of an analysis of the impurities brought down in rain and snow at Mt. Vernon, Iowa, over a period of 8¼ months. The town is small and without manufactories, so that there is no excessive local contamination. The precipitation (22¼ in.) supplied during the period 512 lbs. of chlorine, 1·5 lbs. of sulphates, and 5·3 lbs. of nitrates per acre. The presence of the chlorine has been ascribed to salt particles carried from the Atlantic. The average part per million for free ammonia was 0·407; albuminoid ammonia, 0·366; nitrates, 0·255; and nitrites, 0·018. Rain was found to be richer in nitrogen contents than snow. [See also Abs. 146 (1919).] J. S. Di.

1162. *Under-Suns and Sun-Pillars.* **K. Stuchtey.** (Ann. d. Physik, 59. 1. pp. 33–55, June 13, 1919.)—Under-suns and sun-pillars are among the least frequently observed of all the halo-phenomena, for the reason that the greater part of these halo-forms are below the horizon, and can therefore only be seen by observers on aircraft or on mountains. The under-sun is a mock sun which appears in the position of the optical reflection of the sun itself in the horizon. Sun-pillars are vertical columns of light which are located in the vertical great-circle containing the sun and under-sun. They may extend below the under-sun, between the sun and under-sun, and sometimes above the sun.

The accepted theory of the mode of formation of these phenomena, which are invariably uncoloured, is that they are due to simple optical reflection of the sun's rays in the plane surfaces of countless small plates, spicules or stars of ice of which are composed the highest clouds of the cirrus type. These plates, etc., float in the air between the observer and the apparent position of the phenomenon. The under-sun is due to reflection at *horizontal* surfaces of the particles, while the reflecting surfaces which produce sun-pillars are supposed either to spin in an approximately horizontal position, or to oscillate slightly on both sides of a stable horizontal position, at the same time as the particles themselves gradually fall towards the earth.

The general coordinates of the position of the reflected image in such a surface are determined and developed to show why the resulting visual image assumes the forms and dimensions of the pillars which have been described or photographed. R. C.

1163. *The Okhta Explosion.* **[Prince] B. Galitzin.** (Roy. Soc., Proc. 95. pp. 508–515, July 15, 1919.)—In April, 1915, a violent explosion occurred at the Okhta Explosives Factory, situated about 8 miles NE. of Petrograd. The atmospheric pressure-wave forced open many windows in the capital, and barographs installed in various observatories showed the passage of a well-marked condensation-wave in the atmosphere. But the corresponding change of atmospheric pressure recorded was small, owing, doubtless, to the sheltered position of the barographs, and the actual change must have been much greater than that registered. The seismograms obtained at Pulkova were of great interest. Two distinct impulses were shown. The first was really of seismic origin. The second followed 70 secs. later, and analysis of the records reveals the probability that it was really due to the action of the explosive wave through the air. It is therefore unnecessary to assume the existence of seismic oscillations with abnormally small velocities. W. A. R.

1164. *Long Period in Chinese Earthquakes.* **H. H. Turner.** (Roy. Astron. Soc., M.N. 79. pp. 531–539, May, 1919.)—This paper gives further analyses of the Hirota Catalogue of Chinese Earthquakes [see Abs. 1003 (1919)] and shows a long period of 240 years. Nile flood readings (A.D. 640-1360) show the same periodicity, and Milne's catalogue shows the periodicity faintly. If the periodicity of lunar longitude can be so short as 240 years, and can be identified with a variation of the earth's rotation, associated with a small pulsation in radius, then there are fewer earthquakes when the radius is expanding than when it is contracting, and the dates show good correspondence so far as they go. W. A. R.

1165. *General Auroral Illumination of the Sky and the Wave-length of the Chief Aurora Line.* **V. M. Slipher.** (Astrophys. J. 49. pp. 266–275, May, 1919.)—During the past 3½ years about a hundred spectrograms have been made at the Lowell observatory of the night sky, and every one of these has recorded the chief aurora line. The spectrograph therefore gives direct evidence of the existence of permanent auroral illumination of the sky. The close dependence of displays of aurora upon sun-spot activity suggests that there are variations in the intensity of this general illumination due to the aurora. A preliminary determination of the wave-length of the aurora line indicated a longer wave-length than the commonly accepted value $\lambda 5571$. Further measurements on plates obtained with a higher-dispersion spectrograph gave a mean value for the wave-length of $\lambda 5578{\cdot}05$. The plates showed clearly that the line falls well to the red side of the strong solar line $\lambda 5578{\cdot}075$, and so the value $\lambda 5571$ must be considerably in error. Stark [Abs. 745 (1918)] has put forward the view that the origin of the chief aurora line is probably the nitrogen pair λλ5560, 5565, but the new value obtained for the wavelength renders this view quite inadmissible. A. W.

1166. *Possible Limit to Gravitation.* **F. W. Very.** (Am. J. Sci. 48. pp. 33–46, July, 1919.)—Reasons are given for believing that the sphere of action of a given galactic mass of stellar material does not extend to infinity, but is contained within a definite aural "cell," or is limited by the vortical motions of a particular body of the universal aura which is independent of neighbouring similar bodies. In Messier 101 van Maanen found motions away from the centre, following a law of the inverse cube of the distance, similar to that of magnetic control. The present author considers that the individual motions of stars are like those of molecules of gas, the whole galaxy moving like the gaseous mass, and that failing a boundary of some sort there would be no pressure. Thus the aural cell may be likened to a gigantic "vortex-atom" producing at its boundary a discontinuity sufficient to constitute a cell-wall. Gravitational potential, he says, is a strain in the magnetic medium caused by electrical stresses, and criticises the notion that positive electricity is a minute central nucleus, suggesting a static charge on the surface as an alternative. He next considers the negative electrons associated with the nucleus and rotating rapidly. He thinks the orbital motions give rise to vortices in the magnetic medium which are the cause of inertia and the pulsatory motions produce the changes of density which are the origin of gravity. Spiral orbits (expected in consequence of the inverse cube law) are not all stable, and an electron may have to jump from one stable orbit to another, causing electromagnetic vibrations each time, the number of jumps depending on the temperature, just as in the laboratory from 5 to 12 of the Balmer H series is the limit reached, while the hottest stars show 30 members. The work of Sutherland and See is considered in regard to the bearing of spiral forms on the gravitational problem; and the particular case of Messier 101 is discussed in detail, suggesting that its distance is much greater than has been supposed. The general conclusion is that the larger galaxies resemble discrete and independent, but intimately related, cells of one great organism. W. W. B.

1167. *Sun's Radiation and other Solar Phenomena.* **F. H. Bigelow.** (Review in Astrophys. J. 49. pp. 355–359, June, 1919.)—Starting from the consideration that known temperature gradients are often not adiabatic the author endeavours to replace the usual adiabatic equations by similar ones, but with variables replacing constants. The reviewer is not convinced that this is legitimate, nor successful. Many of the assumptions that have to be introduced appear to be purely speculative and some processes are not explained. The conclusions in regard to solar radiation, the reviewer thinks, may possibly be accepted in the future, but he considers the work at present to be mainly imaginative, and too drastic in its upsetting of many preconceived notions.
W. W. B.

1168. *Outlines of a new Mathematical Theory of Jupiter's Satellites.* **W. de Sitter.** (Review by R. A. S(ampson) in Observatory, No. 541. pp. 281–284, July, 1919.)—The reviewer emphasises the suitability of the problem for a return to arithmetical methods, instead of the generalised expressions in Hill's Lunar Theory, pointing out that both Newton and Euler had recognised the possibility of working from a Variational orbit. The near commensurability of the mean motions of the four great satellites of Jupiter makes them a good test case for comparison of the methods. Several steps in the new method are very similar to the old, and the reviewer, while welcoming the arithmetical adaptability of the method, is inclined to suspend judgment on the results, especially in regard to the adopted masses. W. W. B.

1169. *Blue-Violet Absorption of Venus.* **A. W. Clayden.** (Roy. Astron. Soc., M.N. 79. pp. 507–508, May, 1919.)—A passage in Evershed's Kodaikanal report [see Abs. 410 (1919)], to the effect that Venus spectra are much weaker than cloud spectra in the violet region, from which the inference was drawn that there is a lack of clouds in the atmosphere of Venus, is interpreted quite differently by the author. He draws attention to the fact that light from a bright cloud has passed only once through our atmosphere, whereas light from a Venus cloud has not only done this but also passed twice through the upper atmosphere of Venus, and hence would be expected to show more ultra-violet absorption, especially as the intensity of solar radiation on Venus is much greater than on the earth. Moreover, the paths of the light through the upper atmosphere of Venus will be very oblique, some of them almost tangential.

He infers an atmosphere of Venus very cloudy and similar to our own.
W. W. B.

1170. *Present Position of the Nebular Hypothesis.* **J. H. Jeans.** (Scientia, Oct., 1918. Roy. Astron. Soc. Canada, J. 13. pp. 215–227, May–June, 1919.)—This hypothesis, put forward by Kant (1755) and Laplace (1796) to account for the origin of the solar system, might have been tested, in theory, either by observation or by mathematical analysis, but so far no system anything like the solar system at any stage of probable evolution has been observed, and the work of Poincaré and others has been concerned with homogeneous incompressible fluid and not with the tenuous gas imagined by Laplace. The ultimate result of these investigations points to the regular sequence of sphere, spheroid, ellipsoid, pear-shaped figure, and binary star, followed by fission of the bigger member, and the gradual formation of a cluster. Consideration of density increasing towards the centre led to Roche's lens-shaped model, shrinking by throwing off matter from the edges.

The author finds a discontinuity when the density is about one-fourth of that of water, so that on the ordinary assumption that density increases with age, young stars behave like Laplace's model and old one's according to Poincaré's ideas. These latter appear to be represented by the binary and multiple systems, and the former, in the author's opinion, by the spiral nebulæ. Some of these appear to be lenticular and some have been proved to be rotating. Not one has been seen to throw off matter, but in the critical stage of equilibrium the author suggests that the very small tidal effect of external masses will be sufficient to upset the equilibrium at two opposite points and start the ejection of matter, forming the two-armed spiral. These spirals should all be equi-angular and at 45° by the simple theory of ejected matter, so there is still something more to be elucidated. Nuclei will form at intervals along the arms, and ultimately these would be streams of stars.

It seems, then, that Laplace's hypothesis, though quite inapplicable to the solar system, may after all be accepted for the much greater problem of the evolution of the universe. This idea has not yet obtained dogmatic support, as there are still some weak points in the argument. W. W. B.

1171. *Colours and Magnitudes in Clusters.* XII. *On the Arrangement of the Sidereal Universe.* **H. Shapley.** (Mt. Wilson Solar Observat., Contrib.

No. 157. Astrophys. J. 49. pp. 311–336, June, 1919.)—The large radial velocities found for objects in our own stellar system and the consequent increase in the hypothetical diameter of the galaxy from about 1000 light-years to something of the order of 300,000 light-years, seems to dispose of the theory that globular clusters were island universes, and the inference is now drawn that they are a part of the galactic system, and that knowledge of their distances is probably the best way to gauge the system. The general system of globular clusters resembles the ordinary conception of the sidereal system in being somewhat ellipsoidal, the longest axis being in the galactic plane, but 3000 parsecs away from the sun. The centre of the system is 20,000 parsecs distant, in the direction of Sagittarius, the galactic plane being apparently the main symmetrical plane of the entire known sidereal universe. Most of the stars are in the equatorial segment of the system, and this concentration appears to have a diameter in the plane at least thirty times the thickness of the segment. For some cause, as yet unspecified, globular clusters and other compact systems seem perforce to avoid this concentrated region. Figures are given of the general distribution of the stars near the sun, a subsidiary inference being that the galactic system extends more than forty times as far away as the most distant 6th magnitude (apparent) star. The author sketches the progress of the ideas of the earlier working hypotheses of the dimensions of the galaxy, with an account of the successive modifications. He gives a tentative explanation of the absence of globular clusters from the galactic condensations, suggesting that such clusters scatter on approaching this gravitationally important segment. He points out the difficulty involved in viewing as a simultaneous synopsis stars very widely differing in actual date; the nearest stars being seen as they were a few years ago, while some can only be seen as they were thousands of centuries ago.

Turning to the Local System, he differentiates between members of the general system (field stars) and what he supposes to be a local cluster. This cluster he reckons to include nearly all the B-stars, a majority of the A-stars brighter than 7th magnitude, and a large percentage of the redder stars within three or four hundred parsecs of the sun. He regards this cluster as receding from the centre of the galactic system. He considers separately the various B-types, Cepheids, and other special classes, and discusses the bearing of his conclusions on star-streaming, and gives corroborative evidence from other sources of his deductions that the sun lies to the north of the main plane, that the local cluster is of limited extent, and that the apparent apex of solar motion is bound to vary according to the class of stars from which it is derived. On the whole he supports the ellipsoidal theory against the "dual stream." W. W. B.

1172. *Use of Grating Spectra for Determining Spectral Type and Absolute Magnitude of the Stars.* **B. Lindblad.** (Astrophys. J. 49. pp. 289–302, June, 1919.)—A previous investigation having shown a close relation between effective wave-length and spectral type, the intention was to use the effective wave-length instead of colour-index for inferring absolute magnitudes also. The length of spectrum was examined, and the inner limit found strongly variable, the spectrum being much shorter for later type stars. The minimum wave-length photographed was then taken as a characteristic having regard to its dependence on the conditions and the quality of the apparatus, including the grating and plates. The character of the minimum varies with different types of stars, and the author considers it to be an absorption-equivalent, whereas the effective wave-length is of the nature of a temperature-equivalent. He then gives particulars of the investigation of 35 stars of different spectral types and absolute magnitudes. The material is too scanty for a complete determination of the relations, but generally the inference is drawn that the effective wave-length may be used instead of the spectral class in the determination of absolute magnitude: thus the latter can be determined directly from the effective wave-length and the minimum wave-length in the grating spectrum. The method can be employed for fainter stars with relatively small instruments, and the author draws a further conclusion from his diagrams—namely, that all stars with effective wave-length $\lambda > 433$ $\mu\mu$ are giants.

Investigation is to be continued at Upsala. W. W. B.

1173. *Distance of Milky Way.* **A. Pannekoek.** (Roy. Astron. Soc., M.N. 79. pp. 500–507, May, 1919.)—From several sources, the B.D., the gauges of W. Herschel, the unpublished star-counts of Epstein at Frankfort, and the catalogue and chart plates of the *Carte du Ciel*, the author has investigated the parallax of certain portions of the Milky Way, on the basis of Kapteyn's Luminosity function. He obtains for the bright Cygnus patch a parallax of 0·000025″ and for the Aquila stream of 0·000016″, the corresponding distances being 40,000 and 60,000 parsecs respectively. By another method he obtains limits of 0·000013″ and 0·000040″ for the parallax of the Cygnus patch, which is in good agreement. He thus confirms Shapley's more recent figures, and also his contention that the sun is very eccentrically placed with regard to the galaxy, and near the limit in the Perseus direction. W. W. B.

1174. *Colours of Double Stars.* **H. E. Lau.** (Astron. Nachr. No. 4980. Observatory, No. 541. p. 287, July, 1919. Abstract.)—From observations by Wirtz at Strasbourg, the conclusion is drawn that in the case of early-type stars the companion is generally redder than the primary; in later-type stars the reverse is the case, the transition taking place between F5 and G. For types later than F the companions are relatively red in systems with large P.M. and blue in those with small P.M. Since most of the early-type stars are giants, and most of the later-type dwarfs have large P.M. these results are in general accord with the theoretical conclusions of Jeans [see Abs. 863 (1919)]: "In binaries of mass much below that of the sun, the most massive component ought to develop most rapidly; in binaries of mass much greater than that of the sun the reverse ought to be the case." W. W. B.

1175. *Variations in Ultra-violet Spectrum of Nova Aquilæ.* **C. P. Butler.** (Roy. Astron. Soc. M.N. 79. pp. 498–500, May, 1919.)—Comparing spectrum photographs of the early stages of the nova, on June 8, 9 and 10 by Parkhurst at Green River, Wyoming, the author finds the absorption spectrum on June 8 to be mainly H with Ca (H and K) and a strong line near the strong spark line of Mg, λ4481. On June 9 absorption was intensified, especially in 3 groups, λ3550–λ3585, λ3720–λ3800, and λ3830–λ3840; and still more on June 10. The author wishes to identify the first of these with the strong Sc spark lines λ3558 to λ3581, the second with Ti and Ca, superposed on H_μ, H_λ, H_κ and H_ι, and the third with Mg superposed on H_η. The corresponding groups in the spectrum of the sun and Arcturus are attributed to Fe arc and Mg, so that a change of type may be indicated, possibly from A to G. W. W. B.

1176. *Constitution and Radiation of Gaseous Stars.* **J. H. Jeans.** (Roy. Astron. Soc., M.N. 79. pp. 319–382, March, 1919.)—The author here shows that Eddington's new argument [Abs. 253 (1918)] for the general conclusions previously criticised by the author cannot be accepted without considerable reservations. The independent examination of the present paper shows, however, that his main results may be accepted when the star's only source of energy is gravitation, but not so his reasons. The central assumption is $H/g =$ constant, where H is the outward energy flow, and g the inward gravitational acceleration, throughout a star. It is here shown that so far as Boyle's law is obeyed, this result is true only when the energy is wholly gravitational, or if extra gravitational energy exist, provided its generation per unit mass is independent of the time. This result follows from the observation that (very approximately) the absolute magnitudes of giant stars are independent of the stage of evolution, interpreting the evidence as showing that the radiation of a giant star does not vary with the time. The only conceivable adequate source of extra gravitational energy would appear to be the destruction of matter, and it seems impossible that this should be unaffected by the pressure, temperature, etc., of the star.

Dividing gaseous stellar bodies into those of mass: (1) great relative to the sun (*e.g.*, nuclei of spiral nebulæ); (2) comparable with the sun (*e.g.*, most gaseous stars); (3) very small compared with the sun (*e.g.*, planets, satellites, etc., in the gaseous state), radiation-pressure predominates in (1), is comparable with gas pressure in (2), and is insignificant in (3). The analysis shows that the radiation-pressure may be greater, but not enormously so, than estimates by Eddington. In (1) the emission E is proportional to the mass M, and as the body contracts, the rate of increase of $\bar{\rho}$, the mean density, is proportional to $M^{-2/3}$. In (2) no exact relations are obtainable. In (3) E is proportional to M^3, and $d\bar{\rho}/dt$ to $M^{4/3}$. In a random assortment of stars, those of moderate mass would develop most rapidly, stars of very great and very small mass lagging behind. In massive binaries, the less massive component should be the more developed; the reverse should be the case in binaries of small mass. Finally, the distribution of brightness over the surface of bodies in (1) is considered, with the result that the total emission during rotation is less than if at rest, and the surface brightness at any point is proportional to the distance a free particle would fall in one second at that point under the influence of gravity, centrifugal force, tidal forces, etc.

G. W. de T.

1177. *Spectrum of Nova Aquilæ.* **J. Evershed.** (Roy. Astron. Soc., M.N. 79. pp. 468–490, May, 1919.)—A complete account of photometric and spectroscopic observations of the nova at Kodaikanal from June 10 to July 15, 1918, the spectra selected for measurement being thus obtained on June 12, 13, 19, 20, July 6 and 11. The displacements of the absorption spectrum of hydrogen, indicating velocities of 1600 and 2200 km. per sec. are attributed to masses of hydrogen erupted from the nova sufficiently near the line of sight to have an absorptive effect. The velocities, the author says, are quite comparable with those observed in solar eruptions, and if due to light-pressure they would be naturally greater for the nova during its first outburst. The emission spectrum of hydrogen, the nebular lines, and the early dark-line spectrum are discussed and the special behaviour of the enhanced Fe lines. A full table of identifications is appended and a plate showing typical nova spectra compared with those of Altair or Arcturus. The author, in addition to his own interpretation, discusses points raised by

Plaskett and Newall. **A. L. Cortie** (Roy. Astron. Soc., M.N. 79. pp. 491–497, May, 1919.)—Further detailed examination of the plate taken on this date and previously published [see Abs. 275 (1919)], shows an extension as far as Hλ in the violet, but the measures tabulated are from λλ3886 to 5028, the bright bands being compared not only with α Cygni but with γ Orionis, in consequence of Stratton's paper on Nova Geminorum. The author's conclusion is that though the more recent lines conform rather to the γ Orionis type yet the α Cygni type persists, especially in the fainter bands. Many of the bands are triplets, especially some of the H bands, and the author identifies three spectra: one stationary, one receding with velocity about 1160 km./sec., and one approaching with velocity about 1840 km./sec. W. W. B.

1178. *Photoelectric Measures of Nova Aquilæ No. 3.* **J. Stebbins** and **E. Dershem.** (Astrophys. J. 49. pp. 344–354, June, 1919.)—The nova was missed on the night of June 8, but observations were secured on 79 nights from June 9 to Dec. 10, with a potassium photoelectric cell. To avoid the difficulty of a lack of suitable stars shade glasses were used to make the comparisons nearly equal, under which condition the method works best. The effect of shading varies with spectral type, though the shades were neutral tinted. The range of magnitude of the nova during the period was from −0·5 mag. to 5·5 mag. or rather fainter, and several fluctuations are shown. The measures are corrected for atmospheric extinction, and the probable error of all the measures after June 11 is about $\frac{1}{30}$ of a magnitude. No rapid changes of light were noted. One of the comparison stars, δ Aquilæ, was suspected of variability. W. W. B.

1179. *Nova Aquilæ.* **T. Terada.** (Phys. Math. Soc. Japan, Proc. 1. pp. 180–185, June, 1919.)—The temperature time curve of Nova Aquilæ shows a striking similarity to the frequency time curve of the after-shocks accompanying a distinctive earthquake. The general course of both curves falls off with time gradually, nearly exponentially, but accompanied with remarkable quasi-periodic fluctuations. After an examination as to whether the resemblance of the periodicities may be due to chance, the agreement is still seen to be remarkable and a formal similarity between the phenomena remains. This suggests a comparison between the after-shocks and the causes of temperature variation in a Nova. There may be some mechanical commotions taking place in a Nova, and the radiation may be emitted by a huge number of discrete elementary disturbances. The effective temperature of the radiation is not only determined by the number of present occurrences, but is influenced by previous conditions. W. A. R.

1180. *Three New Spectroscopic Binaries.* **W. E. Harper.** (Roy. Astron. Soc. Canada, J. 13. pp. 237–238, May–June, 1919.)—Work at Ottawa Observatory shows that (1) Boss 839 (α = 3 h. 36 m., δ = + 33°39′, Mag. 5, Type B2) has a variable radial velocity with range about 40 km.; (2) the bright H lines of Boss 947 (α = 4 h. 01 m. δ = + 47°27′, Mag. 4, Type B3) shift by an amount corresponding to 40/50 km. per sec.; (3) 12 Canum Venaticorum (α = 12 h. 51 m., δ = + 38°52′, Mag. 5. 4, Type Ap), which is the fainter of the pair 6313 in Burnham's catalogue, has a variable velocity instead of constant as claimed by Ludendorff. H. F. H.

LIGHT.

1181. *Modern Single-Observer Range-finders.* **J. W. French.** (Nature, 103. pp. 405–407, July 24, 1919.)—Thirty years ago the War Office asked for a range-finder for field service that would measure ranges at 1000 yds. to within 40 yds. The base used was 30 in. In 1892 a naval range-finder was required to work within an error of 3% at 3000 yds. In 1904 the effective range of naval gunnery was 6000 yds., and for this service a range-finder of 9 ft. base was introduced. The 30-ft. base range-finders exhibited by the firm of Barr & Stroud, Ltd., at their stand at the British Scientific Products Exhibition are designed to measure a range of 40,000 yds. to within 330 yds., an error equivalent to 9 in. at 1000 yds. Thus in 30 years the accuracy has been increased 160-fold. This increase has been partly obtained by increasing the base length about 12-fold, and the magnification about 3-fold, thus accounting for a 36-fold increase. The remainder of the increase has been attained by refinements in the design and construction of the optical and mechanical elements. With Barr and Stroud coincidence range-finders, a non-alignment between the images can ordinarily be detected when they subtend at the eye an angle of about 12″, or 0·0000582 in circular measure, though a much smaller angle can often be resolved. If B is the base of a range-finder, M the magnifying power, and R the range, then $\delta R = 0{\cdot}0000582R^2/MB$. At present a magnification of more than 30 diams. is not desirable, owing to the necessity to provide for range-taking in dull light, and other considerations. The modern instruments are provided with internal adjusting devices, variable-power eyepieces, light-filters, and apparatus involving complicated conical gearing for the conversion of the reciprocal scale into a uniform scale of ranges. Provision is now generally made for three operators—namely: the range-taker, who also controls the elevation; the trainer, who is provided with a special sighting periscope; and the scale-reader, who transmits the ranges to the firing control station.

At the beginning of the war no British battleship carried a range-finder of greater base than 9 ft., the length decided upon in 1904. Substitution of longer types of range-finder on ships not intended for them naturally involves extensive structural alterations. At the Battle of Jutland in 1916, firing went on at a range of over 20,000 yds., and although the makers had already constructed range-finders of 15 to 35 ft. base, the majority of the Service range-finders were still of 9 ft. base, the Fifth Battle Squadron alone having been equipped with 15-ft. range-finders. The *Iron Duke,* carrying only 9-ft. range-finders, meant for 6000 yds. range, opened fire at 12,000 yds. There is good reason to believe that the German ships were equipped with range-finders of 20-ft. base, and probably some of 33 ft. While a range-finder gives errors varying according to the square of the distance, unfortunately for a given gun the longer the range the more serious is the effect of the error, owing to the greater angle of descent of the projectile. The advent of aerial craft has necessitated the use of special combined range- and height-finders, which automatically determine the height of the target from its range and elevation. In the case of naval anti-aircraft instruments, the vertical from which the elevation is reckoned is defined by a damped pendulum device. For land purposes, the horizontal can be determined by a good spirit-level. Whereas the range of an approaching aeroplane changes so rapidly that it is somewhat difficult to maintain the coincidence of the partial images in the field of view of a range-finder, the height of the aeroplane remains comparatively constant for considerable periods. It is therefore generally more convenient to measure the height, from which the setting of the gun can be adjusted in relation to a suitable gunsight scale. As the range is a function of the elevation for constant height, an arrangement has been devised for keeping the partial images in coincidence by the simple operation of following the target; the elevating gear being arranged to act upon the deflecting prism of the range-finder through the intermediary of conical spiral gears, equivalent to cams of the requisite form. If the height alters, the partial images can be brought into coincidence again by independent direct operation of the working head. Both heights and ranges are indicated by the instrument. The problem of hitting aircraft at long range is greatly complicated by the necessity of allowing not only for the interval between finding the range and firing the gun, but also for the greater interval between firing the gun and the arrival of the shot at the target. To meet the new and difficult problems involved, predicting instruments have been invented to be used in connection with the range- and height-finders. A. E.

1182. *Possible Disturbance of a Range-finder by Atmospheric Refraction due to Ship's Motion.* **Rayleigh.** (Optical Soc., Trans. 20. pp. 125–134, Feb., 1919.)—The suggestion has been put forward that the action of a range-finder, adjusted for a quiescent atmosphere, may be liable to disturbance when employed upon a ship in motion, as a result of the variable densities in the air due to such motion and consequent refraction of the light. The question is here examined mathematically, taking the case of an infinite cylinder moving transversely through an otherwise undisturbed medium. The conclusion is reached that in the case where the velocity of the cylinder is 25 knots, the max. possible error in each ray is about 0·05″, the action being such as to lead to an over-estimate of the distance. It seems probable that a range-finder, carried well above the deck of a ship, would be less liable to error than in the case considered. In the *discussion*, **A. Barr** stated that the smallest angle assumed to be capable of detection in range-finding practice is about one third of a second of arc, so that the possible error was quite negligible. **T. Y. Baker**, from various considerations, comes to the conclusion that the effect in question is not negligible, and that further investigation is necessary. **W. Taylor** gave the results of tests on 3 range-finders which showed that on certain occasions the instruments would read correctly on objects in a westerly direction, while reading long on objects in an easterly direction. Other results show irregularities amounting to one or two seconds, but no cause for such irregularities could be assigned. Suggestions were put forward that experiments should be undertaken to test the theory. A. W.

1183. *Influence of Various Substances on Light-Absorption by Tungsten Films.* **L. Hamburger, G. Holst, D. Lely, and E. Oosterhuis.** (K. Akad. Amsterdam, Proc. 21. 9. pp. 1078–1088, 1919.)—The introduction of chlorine into tungsten lamps is not suitable for preventing blackening.

Chlorine does not attack tungsten below 200° C. At higher temperatures it forms WCl_6 which dissociates again; the blackening disappears when the lamp burns, but the effect is only temporary. When the chlorine pressure is too low, the glass walls do not get sufficiently hot, and the WCl_6 is not re-evaporated; when the gas pressure is high, the filament may be corroded or some tungsten be deposited upon it. Skaupy had suggested to use the double chloride of potassium and thallium, which slowly evolves chlorine when hot; the almost colourless deposit then formed on the glass walls consists of thallium chloride and chlorine, not potassium. In this way the blackening may be prevented. It had been suggested that cryolite and common salt, proposed for the same process, also evolved free chlorine. The authors show by various experiments that NaCl is not decomposed, but volatilised as such, though the hot tungsten might give off electrons at sufficient speed to discolour the salt as kathode rays do. When two tungsten lamps are joined (by a glass tube) to form a double lamp, and the filament of the lower lamp is coated with salt, that bulb does not blacken; when some of the K_3TlCl_6 is introduced into the lower lamp, both the filaments are protected, because the chlorine penetrates into the upper lamp, whilst the salt volatilised is at once condensed again in the lower lamp. The salt probably prevents blackening because the tungsten particles penetrate into the salt coating and prevent the particles from coalescing to larger aggregates, so that the particles remain in a highly-disperse non-opaque state. Salts like sodium phosphate, tungstate, cyanide, caustic soda, and CaF_2 and NaF behave like NaCl; by the aid of NaCl and CaF_2 the life period during which the lamp intensity kept within 80 % of the original value has been prolonged 2·6 and 3·3 times. [See also Abs. 778, 793, 895 (1918) and 720B (1919).] H. B.

1184. *The Anomalous Double-Refraction of Mixed Crystals.* **G. Tammann.** (Gesell Wiss. Göttingen, Nachr. pp. 226–235, March 3, 1917. Chem. Zentralbl. i. p. 567, 1918.)—The rapid crystallisation of mixed crystals probably interferes with the perfect symmetric distribution in the space-lattice; hence the frequent deviations of the properties from the expected symmetry, and in particular the anomalous double-refraction, which is generally ascribed to strains without explaining the nature of the strain. Since an abnormal mixed crystal must probably be regarded as an unstable system, the normal crystal should have the smaller solubility, and that agrees with observations. Internal strains should, however, affect the solubility by 0·3 % only, whilst solubility differences of 50 % have been observed. The author hence concludes that the anomalous distribution of the molecules in the lattice is directly manifested, and not merely indirectly by the internal strains. H. B.

1185. *Prevention of Steaming on Glass.* **W. Shackleton.** (Optical Soc., Trans. 20. pp. 155–156, Feb., 1919.)—Describes experiments on the efficiency of various lubricants used for the prevention of steaming. The author's preparation consists of glycerine with 20 % of sodium stearate. J. W. T. W.

1186. *Filming of Glass.* **L. C. Martin** and **C. H. Griffiths.** (Optical Soc., Trans. 20. pp. 135–154, Feb., 1919.)—Describes experiments on the nature and method of prevention of film. These include microphotographs of a number of "films" actually occurring in instruments. Cells were made up and the effect of different modes of cleaning, heat and cold treatment, previous immersion in strong acids, the use in the cell of different types of lubricants, etc., were investigated. J. W. T. W.

1187. *Vibration Telescope for Electrodynamometer Measurements.* **C. Barus.** (Nat. Acad. Sci., Proc. 5. pp. 211–217, June, 1919.)—An account of experiments with a form of vibration telescope in which the objective is held in bifilar suspension close to a telephone receiver, the effective current through the latter being measured (a) by the width of image produced by the vibrating objective, and (b) by a Siemens electrodynamometer. Satisfactory agreement between the two sets of readings was obtained. J. W. T. W.

1188. *Radiometer.* **W. Gerlach** and **W. H. Westphal.** (Deutsch. Phys. Gesell., Verh. 21. pp. 218–226, May 30, 1919.)—In experiments described in the present paper, the authors have observed negative radiometer effects with radiometers having metal vanes blackened on one side only. These negative effects are dependent on the gas pressure in the containing vessel, and the results are in agreement with the theory of radiometer action previously given by Westphal [Abs. 1066 (1919)]. This agreement provides fresh evidence in favour of Knudsen's hypothesis of accommodation coefficients depending on the material, since only by the introduction of these quantities can the dependence of the negative radiometer effect on the pressure be accounted for. [See Abs. 970 (1918).] A. W.

1189. *Theory of Half-shadow Polarimeter.* **H. Schulz.** (Deutsch. Phys. Gesell., Verh. 21. pp. 227–235, May 30, 1919.)—A mathematical paper dealing with the theory of the half-shadow polarimeter, with special reference to the dependence of the sensitiveness on various factors. Does not admit of brief abstract. A. W.

1190. *Photographic Mapping from the Air.* **J. B. Mertie.** (Eng. News-Record, 82. pp. 996–999, May 22, 1919.)—A photograph of a plane and horizontal surface taken from the air upon a photographic emulsion held parallel to the plane of the horizon, is a true map. Any relief upon the surface of the object photographed, however, or any inclination between the plane of the ground and the plane of the plate or film vitiates at once the results, and necessitates the making of compensating corrections. In actual practice it has not yet been found possible to hold an aeroplane camera in a truly vertical position. To emphasise these facts, and to point out a line of progress for the correction of these causes of error is the author's purpose.

It is first shown that mere mosaics may be useful in many ways, but they must not be regarded as true maps. One method which has been tried for keeping the camera in a vertical position, is to mount the camera in gimbal rings, and by the use of dash-pots to give the camera the movement of a damped pendulum. The centrifugal force caused by the movements of the plane, however, is sufficiently great to cause a pronounced deviation from the vertical; and, in general, it may be stated that any device dependent wholly on the action of gravity is vulnerable in this respect. With the camera mounted as a gyro-pendulum, measurements of prints show deviations from the vertical ranging up to 2°. A max. deviation of 0·25° from the vertical is probably closer to the desired result. An alternative, however, exists to the complete stabilisation of the camera. If each picture can be referred to a stabilised point, so that the tilt of the negative and the direction of the tilt may be ascertained, such data will be sufficient, with the aid of the necessary instruments and procedure, to rectify the negative to the plane of the horizon. The gyroscope naturally occurs as the means of attaining such a stationary reference point. The sun, being a fixed point in the heavens at any given time on any given day, also suggests itself as a solution of the difficulty, but to this there are certain serious limitations. On the other hand, the problem of the transformation of inclined negatives to orthographic projections, or of the transformation of negatives from any one plane to any other, may be considered as solved. This development in the use of the transforming camera is the possibility of horizontalising, by a method of trial and error, a negative whose tilt and direction of tilt are known, provided the true positions of any three points on the negative are already known. This presupposes that an accurate and detailed horizontal control has already been established, and that three points in favourable positions can be recognised on each negative. Under such conditions an accurate map can be made; but this is only of academic interest, for the same result cannot be duplicated over an unsurveyed area. [See next Abs.] A. E. G.

1191. *Methods in Aëro-photographic Mapping.* **F. H. Moffit.** (Geographical Rev. Eng. News-Record, 82. pp. 1000–1004, May 22, 1919.)—The investigation here described falls naturally into two divisions, of which the first deals with the aeroplane camera—that is, with photographing the terrain, the second with correcting the inclined pictures and the study of the principles involved, and the design of the transforming camera. The difficulty of obtaining a lens which shall have speed, and at the same time a wide angle of view, is met by constructing a multiple camera with its three lenses and focal planes so arranged that the central plane shall be in a horizontal position, and the other two inclined at a fixed angle to it. The side pictures, because of their inclination, include areas outside the field of the central picture, but overlap it slightly, so as to give the means of joining them. To mount the camera in the aeroplane, a hole is cut in the bottom of the fuselage in front of the observer's seat, and a cradle, closed below by a sliding door for the protection of the lenses, is fastened securely to the floor. This cradle is padded with felt or sponge rubber, and the camera is strapped securely to it. Some cameras are mounted on gimbal rings whose movement is damped by a dash-pot arrangement. The observer making the exposures does not rely on a time interval for getting properly spaced pictures, but is chiefly dependent on a large negative lens about 6 in. square, which is set in the bottom of the fuselage and enables him, as he views objects below him, to judge both the direction and rate of movement over the terrain. The principle of the transforming camera is described in detail, and its use illustrated by photographic pictures. The chief sources of difficulty that arise in making maps from aeroplane photographs lie, first, in the lack of suitable means for obtaining the data for transforming the inclined pictures into a truly horizontal position; and, second, in the errors introduced into the pictures by relief of the terrain. The advantage of the aeroplane photographs is also discussed. [See preceding Abs.] A. E. G.

1192. *The Fundamental Law for the True Photographic Rendering of Contrast.* **A. W. Porter** and **R. E. Slade.** (Phil. Mag. 38. pp. 187–197, July, 1919.)—The modern treatment of the character of a photographic plate is based entirely upon the method of examination introduced by Hunter and Driffield. Their great conclusion was that it was necessary and sufficient that D should be a linear function of log E for a sensitive plate; that is, $D = \gamma(\log E - \log i)$. This conclusion appears to have been arrived at by considering a single kind of plate only for both negative and positive, but they do not state exactly what assumptions they made. It would seem from the present paper that they were led to an imperfect conception of the true conditions for securing a true representation of gradation. The true result is in one case more special than theirs, because for similar plates the value of γ must be unity.

It is also more general than theirs, because it is not restricted to the linear function at all. Two particular cases are examined in detail. It is also shown that if the characteristic curve D, against log E, be drawn on tracing paper, and be then viewed *from the back*, so that the first origin O is at the top right-hand corner, the curve, as it then appears, is the characteristic curve of the conjugate plate. The new origin O″ may be any point whatever, the constant amounts by which it is shifted in the two directions being connected with the viewing light and the printing light. To choose the point O″ is equivalent to deciding upon particular values for the printing and viewing lights, and the reduction factor K. The more nearly K approaches to unity the more nearly will the light from the positive be not only the same in gradation as that from the subject, but also the same in absolute intensity. A. E. G.

1193. *Photography in Research.* **A. G. Eldredge.** (Met. and Chem. Eng. 20. pp. 506–510, May 15, 1919.)—The author describes the application of photomicrography to the study of petrology and metallography. The application of kinematography to the study of the effect of alternating stresses is also dealt with, and a number of motion pictures taken during the stressing of wrought iron by repeated bending are reproduced. F. C. A. H. L.

1194. *Effect of Colour of Light on Acuteness of Vision.* **C. E. Ferree** and **G. Rand.** (Am. Illum. Eng. Soc., Trans. 14. pp. 107–116; Disc., 117–132, April, 1919.)—The tests described form a continuation of those previously reported by the authors, comparing the fatigue produced in the eye by reading respectively with light from the kerosene oil lamp, and with various electric glow-lamps [Abs. 459B (1918)]. Former tests indicated that fatigue was apparently less with the oil lamp, thus supporting the belief that yellowish light has certain advantages for vision. The present tests were conducted in the same manner as the former series, a comparison now being made between the oil lamp and a series of incandescent mantles, having a progressively increasing ceria content (from 0·25 % to 5 %). In each case the source was placed behind and to the left of the observer in a position judged to give the conditions most favourable to reading, and the intensity of illumination on the printed page was maintained constant throughout. The test consisted in observing the proportion of time during which type, regarded steadily for three minutes, appears respectively clear and blurred, this ratio being regarded as an indication of the state of efficiency of the eye. Tables and diagrams are presented, indicating that the loss in efficiency, so defined, during a 3-hour test, becomes greater as the percentage of ceria is less, *i.e.* the light becomes greener in tint. The conclusion is drawn that, on the above basis, an unsaturated clear yellow gives a better result than an unsaturated yellow light tinged with green. By some of those taking part in the discussion, these and the former results are regarded as supporting the conclusion that yellow and reddish light is more favourable to efficiency of vision than light from the green and blue region of the spectrum. J. S. D.

1195. *Persistence of Vision for Colours of Varying Intensity.* **F. Allen.** (Phil. Mag. 38. pp. 81–89, July, 1919.)—The author uses an apparatus comprising a rotating sector and two Nicol prisms, through which light is directed into a spectrometer. By adjusting the speed of the sector disc observations on persistence of vision for different parts of the spectrum can be made, the intensity being varied by altering the angle between the planes of the nicols.

Curves are exhibited illustrating persistence of vision throughout the spectrum with progressively increasing intensity, and corresponding luminosity curves are deduced. Data show agreement with the Ferry-Porter Law and support the duplicity-theory of v. Kries, according to which a transition from cone- to rod-vision occurs at low luminosities. The influence of the Purkinje-effect can also be traced. It is remarked that critical frequency or persistence is not simply dependent on luminosity, but colours *per se* have independent effects of their own. J. S. D.

1196. *Variation in Persistence of Vision in different Regions of the Retina.* **P. Woog.** (Comptes Rendus, 168. pp. 1222–1224, June 16, 1919.)—The author describes various simple experiments to show that the max. persistence of vision is located at the fovea. Thus if a black disc with white sectors is driven at such a speed that the impressions fuse to direct vision, a flicker reappears when the disc is observed obliquely. Similar experience is recorded if a white plate, illuminated by a tungsten filament operated at 25 cycles per sec., is observed: the experience is again similar if the light is coloured blue, green, yellow, or red. The area of the retina corresponding to greatest persistence of vision can be easily defined if the limiting distances at which flicker is evident, with diaphragms of varying diameter, is noted. The area is found to correspond with a visual angle of 9° and to be in fact identical with the foveal region. J. S. D.

1197. *The Four Transition Points in the Spectrum and the Primary Colour Sensations.* **F. Allen.** (Phil. Mag. 38. pp. 55–81, July, 1919.)—The experiments relate to persistence of vision by light of different colours. Light from an acetylene flame is intercepted by a sector disc, and subsequently collected and passed through a prism, a spectrum being obtained. Any part of this spectrum can be observed and the speed of rotation of the sector disc adjusted until flicker is only just perceptible. A second spectrum is also produced from an arc, and the eye is fatigued by steady observation of any section thereof for about three minutes, previous to the observation of flicker. Thus curves of persistence of vision throughout the spectrum are obtained with the eye successively fatigued by different colours and are compared with the normal curve corresponding to exposure to diffused daylight. Deviations from the normal curve are noted for the various colours. There are, however, certain narrow bands of colour, *e.g.*, $\lambda = 0{\cdot}660\mu$, $0{\cdot}570\mu$, $0{\cdot}470\mu$, and $0{\cdot}420\mu$, where no perceptible effect on persistence of vision is evident. This is illustrated by a family of curves, and the author concludes that the fundamental red, green, and violet sensations can be assigned positions with reference to these transition points. Confirmatory evidence has been obtained by observation of colour-blind persons. J. S. D.

1198. *Metallic Spectra produced in High Vacua.* **[Miss] E. Carter** and **A. S. King.** (Mt. Wilson Solar Observat., Contrib. No. 166. Astrophys. J. 49. pp. 224–236, May, 1919.)—Using the methods previously employed [Abs. 396 (1917)] the authors have made a study of the spectra of Mn, Ti, Mg, and Cd, as produced by vaporising the substance through the heating effect of a stream of kathode rays, and exciting the vapour to luminescence by the bombardment of the kathode particles. The spectrum of iron was obtained by making the antikathode the anode, but photographs of the magnesium spectrum made in both ways indicated that, although the spectrum was more intense when the metal acted as anode, it did not differ in character from that produced with a separate anode so placed that the antikathode was out of the path of the current. Comparison of these luminescence spectra with the arc, spark and furnace spectra of the same elements shows that, although in general the majority of the lines are those easily excited in the arc and furnace, the following peculiarities mark this source as having special characteristics. (1) Certain arc and furnace lines are intensified, while other lines, strong in these sources, are greatly weakened or are absent. (2) The resemblance to the spark spectrum, as measured by the tendency to give enhanced lines, differs greatly for different elements. The production of enhanced lines is very marked in the case of Cd; they are present also to a considerable extent with Mg and Ca, but to a very slight degree for Ti, Mn, and Fe. (3) Where series relations are known, "single-line" series are likely to show a relatively greater intensity than other series lines. (4) There is a relatively high intensity of lines in the ultra-violet as compared with the arc and furnace spectra. A. W.

1199. *Series Lines in Spectra.* **M. Ritter.** (Ann. d. Physik, 59. 2. pp. 170-184, June 20, 1919.)—A series of measurements was made of the Stark-effect for certain lines of Zn, Hg, Li, and Ca. Observations were also made of the pressure-shift and broadening of the lines due to large current density and gas pressure in the discharge tube. The results show that the effect of an electric field, the pressure-shift, and the dissymmetrical broadening of the lines belonging to a particular series, increase along the series with increasing member number, and consequently with decreasing wave-length. It was also found that the sign of the displacement due to an electric field is, without exception, in agreement with the sign of the pressure-shift and with that of the dissymmetry. Stark's hypothesis that the pressure-shift and the dissymmetrical broadening of series lines are due to molecular electric fields is supported by the results now obtained. [See Abs. 1071 (1914).] A. W.

1200. *Series System in the Spectrum of Gold.* **W. M. Hicks.** (Phil. Mag. 38. pp. 1-31, July, 1919.)—A continuation of previous work [Abs. 217 and 1357 (1917)]. The present paper deals with the series relations in gold. Certain results are arrived at which afford striking illustrations of the general laws previously given. Among the more important results of the discussion are the following:—(1) The existence of a D set corresponding to order $m = 1$ far up in the ultra-red, whose satellite mantissa conforms to the general rule of being a multiple of Δ. Gold therefore does not form an exception, as formerly appeared to be the case. (2) The indication given of the existence of summation lines for the P and S series. In general, such lines for S and P will lie far down in the ultra-violet, and this is no doubt one reason why they have not previously been recognised. The evidence here given must be sustained by further numerical coincidences obtained in other spectra before it is regarded as conclusive, but it is sufficient to render it extremely probable. (3) The more accurate determination of the "oun" depending on the relation $81\delta = \Delta = 113951 - 6p$, where $0{\cdot}1p$ angstroms is an observational error. This result gives $\delta = 1406{\cdot}802 - 0{\cdot}074p$. Taking the ratio of δ to $(W/100)^2$, where W is the atomic weight, to be $361{\cdot}75 + 0{\cdot}05q$, the resulting value of the atomic weight of gold is $197{\cdot}2024 - 0{\cdot}0052p - 0{\cdot}0136q$. A. W.

1201. *Series Spectra.* **W. Kossel** and **A. Sommerfeld.** (Deutsch. Phys. Gesell., Verh. 21. pp. 240-259, May 30, 1919.)—In this paper spark spectra are assumed, as in Bohr's theory, to be associated with ionised atoms, while flame and arc spectra are associated with neutral atoms. Various considerations lead to the conclusion that the spark spectrum of each element corresponds in character to the arc spectrum of the element preceding it in the periodic system, consisting of doublets, triplets, or lines apparently not arranged in series, according as the arc spectrum of the preceding element is made up of doublets (as in the alkalies), triplets (as in the alkaline earths), or of lines having no apparent series arrangements (as in the rare gases). A principle of selection of series lines is given which is shown to yield results in agreement with experimental work for numerous substances. Special consideration of the spectra of the alkalies and alkaline earths leads to the conclusion that the doublet systems of the alkaline earths are spark spectra. Their character as doublet systems is accounted for by the doublet character of the arc spectra of the alkalies, and between the spark spectrum of one of the alkaline earths and the arc spectrum of the alkali directly preceding it there exist simple numerical relations. Similarly it appears that the spark spectra of the earths are triplet systems of the same character as the arc spectra of the alkaline earths; and a definite relation exists between a particular triplet of one of the earths and the corresponding triplet of the alkaline earth preceding it. A. W.

1202. *Series in Absorption Spectra.* **F. Vlès.** (Comptes Rendus, 168. pp. 1044-1047, June 2, 1919.)—A study of the absorption spectra of various substances has shown the existence of series in the absorption spectra of solutions of solids belonging to very different groups. These series relations do not resemble the Balmer type or its well-known derivatives in line spectra, but are more like the Deslandres type relative to the arrangement of the heads of band spectra. The wave-lengths are thus given by a formula of the type $\lambda = \lambda_0 + An + Bn^2 + Cn^3 + \ldots$(1). In a complex spectrum, the selection of bands corresponding to the formula (1) can be effected easily by means of the characteristic relation $(\lambda_4 - \lambda_1)/(\lambda_3 - \lambda_2) = \text{const.} = 3$, which is obtained from (1) by neglecting the term of the third degree. For potassium permanganate in aqueous solution, $A = -24{\cdot}65$, $B = +1{\cdot}00$, $C = -0{\cdot}022$, and the calculated wave-lengths, using these numbers, agree very well with Formanek's results for $n = 0$ to 7 and $n = 19$. The results for the hæmoglobins are specially interesting, as they show relations between the serial characteristics and the chemical constitution. The spectra of a large number of hæmoglobin derivatives (methæmoglobin acid, different hæmatin acids, sulphohæmoglobin, oxyhæmoglobin, etc.) appear to be based on one and the same series ϕ. Other derivatives (more particularly alkaline; alkaline methæmoglobin, cyanhæmatin, alkaline hæmatins, etc.) are represented by a second series ψ, which appears to resemble a prolongation of the first series ϕ. Other derivatives include both spectra. In this group of substances the series ϕ undergoes displacements (in λ and in the value of n for certain characteristic bands taken as datum lines) corresponding to the chemical modifications. In the family of chlorophylls a series is found precisely the same as the ϕ series of the hæmoglobins. Neodymium chloride has a large number of bands represented by a more simple series, being to a certain extent intermediate to the types of series for gases and vapours. The term in n^3 is practically zero, and the formula becomes comparable with that of Miss Lowater for gaseous SO_2.
A. W.

1203. *Band Spectra and Constitution of the Atom.* **H. Deslandres.** (Comptes Rendus, 168. pp. 1179–1185, June 16, 1919.)—In a previous paper [Abs. 1044 (1919)] the author has given a formula for band spectra with three variables or independent parameters m, n, and p. The formula exhibits three arithmetic progressions which determine the distribution. The progressions B and C fix the heads of the bands, and the progression, whose ratio $f(n^2p^2)$ is variable, gives the rays which compose each band. Each progression is represented by a term of the form $A(m+a)^2$, this form having been chosen especially for comparison with line spectra, for which the formula is the inverse of this. The second term of the formula corresponding to progression B, is always additive, and the third, corresponding to progression C, is always subtractive. This property is characteristic, and has been verified by means of 17 band spectra. The author suggests that the classification of band spectra, in which at present there is much confusion, should be submitted to an international congress, and a scheme is put forward for systematising the whole subject. The scheme is illustrated by a tabular presentation of the bands of aluminium. Certain substances exhibit bands showing only a negative or a positive progression, and the formula previously advanced does not appear to be general enough to take account of such deviations from the more usual band spectra. Accordingly the following formula is proposed:

$$\nu = \pm\left[\frac{F(n^2p^2)}{2} \times m^2 + f_1(n^2p^2) \times m\right] + \left[\frac{B}{2} \times n^2 + b_1 n\right] - \left[\frac{C}{2} \times p^2 + c_1 p\right] \pm K,$$

m, n, p being successive integers, positive and negative; and b_1 and c_1 being constants independent of B and C. All known band spectra can be represented by this more general formula. A later paper will discuss the principal characteristics of band spectra, resulting in a natural classification which has applications to the study of atomic structure. A. W.

1204. *Band Spectra.* **T. Okaya.** (Phys.-Math. Soc. Japan, Proc. 9. pp. 195–214, June, 1919.)—In a previous paper referring to the group of banded spectra emitted by Cu, Ag, and Au which diverge gradually towards the red [Abs. 1039 (1919)] the author found that a simple relation exists between the wave-lengths of the heads of the bands, such that, if they are suitably combined, the ratio of the radii of Nagaoka's atomic models which give rise to the banded spectra, is equal to that of the integral numbers, and the ratio of the wave-lengths of the heads can be represented in terms of their atomic weights and the ratio of the integers mentioned above. The present paper deals with the group of elements Be, Ca, Ba, Sr and Mg, and it is shown that a relation similar to that which applies to Cu, Ag, and Au, applies also to these elements. A. W.

1205. *Energy Distribution in Spectrum of Acetylene Flame.* **E. P. Hyde, W. E. Forsythe and F. E. Cady.** (Frank. Inst., J. 188. pp. 129–130, July, 1919.)—Independent tests of the black-body temperature of a cylindrical acetylene flame were made at the Bureau of Standards and the Eastman Kodak Laboratory. The mean result was 2360°K. ± 10°. The agreement between the spectral distribution of the flame and that of a black body at this temperature was within the limits of error except possibly beyond 0·70 μ where there was indication of a higher emissivity for the acetylene. A test of the sensitivity of the colour-match method to show differences in the spectral energy curve showed that if two spectral curves matched at 0·5 μ and 0·7 μ and differed by as little as 4% in the middle of the spectrum, the two sources could not be made to match in colour.

J. W. T. W.

1206. *Spectra and Atomic Numbers of the Elements.* **J. E. Paulson.** (Astrophys. J. 49. pp. 276–281, May, 1919.)—This paper gives the results of an attempt to discover that function of the atomic numbers of the elements which will best represent the observed values of the frequency-difference ν between the lines belonging to the first doublet or triplet of the principal series. Adopting Rydberg's system of classification, it is shown that the formula $\nu = \mathrm{A} \log (\mathrm{N} + n) + \mathrm{B}$, gives good agreement with the experimental results for a number of substances. N here is the atomic number, n a whole number (which may be positive or negative, and is generally small), and A and B are constants. Tables are given of the values of A and B for various groups, with applications of the formula to various elements in each group. A. W.

1207. *Distribution of Energy in the Spectrum of Erbium Oxide.* **W. S. Mallory.** (Phys. Rev. 14. pp. 54–66, July, 1919.)—The investigation described in this paper was undertaken in part to determine, if possible, whether the peculiar emission spectrum of erbium oxide, when heated to incandescence, is a purely thermal radiation, as indicated by the excellent agreement, at the same temperature, in the position of the emission and absorption bands, or whether it might not be a case of luminescence, excited perhaps by the short wave-lengths of the flame used for heating the specimen under observation. Another purpose was to determine for different wave-lengths the relation between the intensity of the radiation from the oxide, and the intensity of the radiation from a black body at the same temperature. Preliminary experiments showed that the peculiar banded emission spectrum of erbium oxide is due to the oxide itself, and requires nothing more than a sufficiently high temperature to bring it out. The manner of obtaining this temperature seems to be of no importance. The emission bands at 1000° C., especially in the green, were found to radiate much more strongly than a black body at the same temperature. The temperature at which the emission of the green band equals that of a black body at 1000° C. is about 900° C. This difference of temperature is much greater than that which could possibly have existed in the comparisons which were made under conditions where approximate equality of temperature was indicated.

In an explanatory note, **E. L. Nichols** discusses the results obtained by Mallory, and states that the evidence appears to favour luminescence superimposed upon ordinary thermal radiation, as an explanation of the phenomena here described. A. W.

1208. *Stark-effect for Lithium.* **U. Yoshida.** (Kyoto Coll. Sci., Mem. 3. pp. 161–171, June, 1919.)—The arrangement of apparatus was essentially the same as previously described [Abs. 955 (1917)], Lo Surdo's method [Abs. 666 (1914)] being again used. The lines examined were λλ6103·8, 4602·4, 4132·4, and 4148·2. The first of these showed no effect in a field of about 80,000 volts/cm. Only two *p*- and two *s*-components were observed for λ4602. The weak central one observed by Stark did not make its appearance. The results for this line support Saunders' conclusion that it is a double line with a separation of 1·6 Å.U. For λ4132, two outer *p*- and *s*-components were found, whose displacements were proportional to the field strength, and a central *p*- and *s*-component displaced a little towards the violet. The line λ4148·2 was displaced more towards the red as the field strength was increased, the displacement being proportional to the field strength for both *p*- and *s*-components. The intensity of this line diminished as the field-strength decreased, and at last vanished when the field-strength fell below about 15,000 volts/cm. Certain points of similarity between helium and lithium lines are noted, and the peculiarity of the Li lines λ4602 and λ4148·2 in an arc is explained as the effect of an electric field on these lines. A. W.

1209. *Stark-effect for Calcium and Magnesium.* **T. Takamine** and **N. Kokubu.** (Kyoto Coll. Sci., Mem. 3. pp. 178–181, June, 1919.)—Using Lo Surdo's method, the Stark-effect for 14 Ca lines and 5 Mg lines was investigated. Detailed quantitative results are given for 7 Ca and 3 Mg lines, with separation diagrams and photographs. The greatest field strength used was about 90,000 volts/cm. All the lines were found to be displaced either towards the red or towards the violet in the electric field. In general, the lines belonging to the same series are affected in nearly the same way, and, further, each of the lines constituting a triplet was affected in a similar manner. This latter statement is well illustrated by the three calcium lines λλ4099, 4095, 4093, belonging to the "narrow triplet" series. An exceptional case seems to be the magnesium triplet λ3838, 3833, 3830; but as these lines are only very slightly affected, further experiments, using higher dispersion, are necessary to determine whether the triplet is really exceptional or only apparently so. A. W.

1210. *Stark-effect for Oxygen and Nitrogen.* **U. Yoshida.** (Kyoto Coll. Sci., ;Mem. 3. No. 10. pp. 287–297, March, 1919.)—The methods employed were similar to those used by Takamine and Kokubu [see three preceding Abs.]. Only a negative result was obtained by Stark for the band spectrum of nitrogen, and no effect of an electric field on either oxygen or nitrogen seems to have been obtained previously. Using intense fields, however, a positive result was obtained in the present experiments for the lines λ4100 and λ4110 of nitrogen, and for some of the lines belonging to the first and second subordinate triplet series of oxygen. Excepting a few ambiguous cases, the amount of the displacement or of the separation of each of these lines is nearly the same for the *p*- and for the *s*-components. The behaviour of the lines of the second subordinate triplet series of oxygen in the electric field is similar to that of the lines belonging to the second subordinate series of helium and parhelium. The effect on the lines of the first subordinate triplet series of oxygen is greater than that on the second subordinate triplet series. Each of the lines λ5329·5 and λ4968·5, of the first subordinate triplet series, has two isolated components on the immediate violet side. The separation of these isolated components from the principal line becomes smaller as the term number increases, just as in the case of the isolated components of helium and parhelium. A. W.

1211. *Effect of an Electric Field on Argon Lines.* **T. Takamine** and **N. Kokubu.** (Kyoto Coll. Sci., Mem. 3. No. 9. pp. 281–285, March, 1919.)—Nyquist [Abs. 953 (1917)] has examined the Stark-effect for neon. The present paper gives results for argon, which does not appear to have been investigated before. The arrangement of apparatus was similar to that used in previous investigations of helium and hydrogen [Abs. 839, 942 (1918) and preceding Abs.

The Stark-effect for argon is extremely small compared with that for helium and hydrogen. It was only by using very strong fields that a group of 16 lines in the violet region, from λ4933·5 to λ4046·0, was found to be displaced towards the red. The greatest field strength employed was calculated to be about 170,000 volts/cm., Stark's data for the line $H\beta$ being assumed to hold good. It is remarkable that nearly all the affected lines belong to the "red spectrum" of argon. Thus, so far as the present experiment is concerned, the so-called arc lines seem to be more easily affected by an electric field than the spark lines. This is in conformity with the results previously obtained for the Stark-effect on the lines of He, Ca, and Hg. Besides the argon lines, a mercury line λ4889 was found to be displaced about 0·7 Å.U. for the *p*-component, and 0·5 Å.U. for the *s*-component, towards the red in a field of 58,000 volts/cm. Photographs are given. A. W.

1212. *Effect of an Electric Field on Hydrogen Lines.* II. **T. Takamine** and **N. Kokubu.** (Kyoto Coll. Sci., Mem. 3. No. 9. pp. 271–278, March, 1919.)—The arrangement of apparatus used in the experiments here described was essentially the same as in the earlier work [Abs. 889 and 942 (1918)], Lo Surdo's method [Abs. 666 (1914)] being again used; but a tantalum kathode was substituted for the Al one previously employed, the sputtering of the kathode being thereby considerably decreased. Further, by reducing the pressure until the end of the Crookes' dark space became quite indistinct, the max. field strength was increased to about 150,000 volts/cm. One remarkable new feature observed in the present experiments was the shift of the central line in the perpendicular component of $H\gamma$ in a strong electric field. The amount of the shift was about + 1 Å.U. at field strength 130,000 volts/cm. In a few cases, a shift of the central *s*-component was also observed for the line $H\epsilon$, but the data up to the present are insufficient to make any definite statement about this line. The shift has been observed also for the helium lines λ4026 and λ4388, which correspond to the same term number ($n = 5$) as the $H\gamma$ line. There is a decided similarity in appearance between the helium line λ4388 and $H\gamma$. Stark's observation of 6 *p*- and 8 *s*-components of $H\alpha$ was confirmed, using a 6-in. plane grating with Littrow mounting. Eleven more lines in the secondary spectrum of hydrogen have been found in the region below λ4000. As noted by Stark, the great difference in the Stark-effect for Balmer lines and for secondary lines seems to suggest that they are due to different sorts of carriers. It is remarkable that all the affected lines are of rather weak intensity. With a dispersion sufficient for detecting 0·3 or 0·4 Å.U., no influence of the electric field was observed for the group of strong lines λλ4634, 4632, 4583 and 4580, even in the strongest fields. In connection with this it may be noted that no electric effect was observed for the nitrogen bands in such fields (150,000 volts/cm.).

Numerous photographs are reproduced. A. W.

1213. *Effect of an Electric Field on Helium Lines.* III. **T. Takamine** and **N. Kokubu.** Kyoto Coll. Sci., Mem. 3. No. 9. pp. 275–280, March, 1919.)—Similar arrangements were adopted to those used for hydrogen [see preceding Abs.]. In addition an echelon grating with 10 plates was in some cases placed behind the collimator of a single-prism spectrograph. Including the results of previous work [Abs. 1098 (1918)], 26 helium lines have been examined. The lines λλ4438, 4121 and 3965, which up to now have been regarded as being merely shifted by an electric field, were found to be resolved into a number of components, all being shifted in the same direction. The Stark-effect for λ4388 and λ4026 is similar to that for $H\gamma$ in that the central *s*-component is the strongest of all the components and is shifted towards the red as the field strength is increased. As regards faint components, such as those of λλ5876 and 4472, it has been found that the starting-point of such isolated components approaches nearer and nearer to the main line as the term number in a series is increased. For the lines λλ4388 and 4026, an isolated component which appears first on the immediate violet side of the initial line is shifted toward the red side as the field strength is increased, and finally, in fields of over 120,000 volts/cm., it comes out on the red side of the initial line. Further, the strong *s*-component which first appears on the immediate violet side of the main line is seen to cross through another component as the field strength is increased. A similar phenomenon of the birth of a new component was observed by Paschen and Back for the line λ4388 when studying the Zeeman-effect [Abs. 419 (1918)]. According to them, the position of this new satellite is — 0·5 Å.U. from the inital line. This position almost coincides with the starting point of one of the isolated components observed in the present experiments. Numerous diagrams, showing line separations, and photographs are given. [See Abs. 1668 (1915).] A. W.

1214. *Fluorescence.* **J. Perrin.** (Ann. de Phys. [ix] 10. pp. 133–159, Sept.–Oct., 1918.)—Various aromatic compounds dissolved in water, alcohol, xylol, and glycerin are studied with the ultra-microscope. The emission of fluorescence goes together with a destruction or transformation of the chemical molecule which probably is fluorescent only during that destruction. The recovery depends upon the diffusion of fresh, unaffected particles into the illuminated field, and is rapid in water and slow in glycerin; an isolated drop of uranin (sodium fluoresceinate) soon loses its fluorescence and does not recover it in the dark, remaining dark. Temperature (boiling water, glycerin solution in liquid air) has no influence. Fluorescence is thus analogous to the fading of colours. In character this molecular fluorescence resembles the atomic fluorescence produced by kathode, Röntgen, and radium radiations. When the expulsion of an electron is accompanied by light-emission, fluorescence is observed; phosphorescence goes together with the reintegration of the electron, and this latter light-emission persists and is facilitated in solid substances by agencies which diminish the rigidity (thermoluminescence). There is an optimum fluorescence for a certain concentration of the compound, which is very difficult to explain. But fluorescence appears limited to the breakdown of molecules under formation of other molecules; the exciting light is not strictly homogeneous, and the fluorogen molecules it meets are not all in a condition to respond in resonance so that the number of efficacious encounters is very small. The energy relations are discussed, and it is pointed out that the red fluorescence from three black spots on soap films, 6, 10, and 15 $\mu\mu$ in thickness respectively [see Abs. 1146 (1919)], was strongest for the intermediate thickness (10 $\mu\mu$). In the thinnest film the fluorogen molecule is unprotected; when the thickness is increased, the individual molecule is, within limits, stabilised by neighbouring molecules. H. B.

1215. *Energy Distribution in the General X-ray Spectrum.* **D. L. Webster.** (Nat. Acad. Sci., Proc. 5. pp. 163–166, May, 1919.)—In the spectra of X-rays as ordinarily determined there are factors of absorption in the antikathode, the glass of the tube, the reflecting crystal, and the ionised gas, and of efficiency of reflection that are all functions of the frequency. Fortunately, except at the discontinuities of any of these absorptions, the unknown factors vary continuously with frequency, so that the measured intensities in the spectrum represent the energy distribution qualitatively, but not quantitatively. The author now considers the problem of combining other available data in such a way as to find an approximate law of energy distribution not involving unknown absorption factors, and avoiding also any *a priori* assumptions about the emitting mechanism. The data are incomplete, and this work is merely a first approximation. A. B. W.

1216. *Life-Periods, Atomic Masses, and Changes of Radio-Elements.* **E. Kohlweiler.** (Zeits. Phys. Chem. 92. pp. 685–716, June 18, 1918.)—An extension of the suggestions of Fajans as to regularities in the stability, life-period, and other properties of the radio-elements, amongst which valency plays an important part. The valencies (groups) range from uranium (VI) down to the value 0 which he assigns to the emanations of Ra, Th, Act. In each disintegration series, the members of which emit α-rays and have even valencies, the life-period is the longer the greater the atomic weight, whilst in series of β-ray change the period grows with decreasing atomic weight, both for odd and even valencies. For elements of contiguous valencies (*e.g.*, IV and V) and α-ray emission, the life is greater for the smaller valency, independent of the atomic mass. Some exceptions to these rules (RaD) and further rules occur in the less well investigated series. The question of isotopes and of identical and analogous elements and the relation to the periodic law are discussed; for actinium the atomic mass 226 is suggested.

In his table of the radio-elements the author ascribes to uranium I (and II) the valency VI, the atomic masses 218 (234), 119 + and 49 — (117 +, 47 —) elementary charges, 8 + and 6 — (13 +, 6 —) groups of elementary charges, and 7 + and 1 — (3 +, 7 —) ungrouped elementary quanta. These considerations are further developed in the following paper. H. B.

1217. *Atomic Structure on the Basis of Atomic Disintegration.* **E. Kohlweiler.** (Zeits. Phys. Chem. 93. pp. 1–42, July 9, 1918.)—To say that sodium chloride consists of 1 atom of Na and 1 of Cl is correct merely in quantitative respect; qualitatively it is not, and NaCl has not the properties of either Na or Cl.

The model atom of the author is very complex. In the atomic nucleus he has, *e.g.*, one group of negative charges, surrounded by groups of positive charges; about the nucleus is first the neutral ring of positive and negative systems; then two rings, one of free positive, the other of free negative elementary quanta, these making up the middle zone; finally, the external zone of electrons. The chemical character depends in the first instance on the middle zone. Carbon$^{\text{IV}}$ would (in CO_2, *e.g.*) have 4 valency systems and 4 + charges, carbon$^{\text{II}}$ (in CO) would have 2 valency systems, but also 4 + charges. Lead is of valency IV, that is, the atom has 4 valency systems; but 2 electrons may segregate and pass into the outer ring; then Pb has only 2 valencies like mercury, but it retains its 4 + elementary quanta, of which mercury possesses only 2. Valencies generally change in steps of two; thus sulphur has the valencies 2, 4, 6, chlorine 1, 3, 5, 7. One particular valency is generally found to be preferential.

That atomic weights differ from integers is due to the presence of isotopes. Iodine and tellurium are both mixtures, in different proportions, of isotopes of masses 126 and 128 respectively. The peculiarities of the periodic system are explained in similar ways, and the models are to account for thermal and electrolytic dissociation. H. B.

HEAT.

1218. *New Determination of the Expansion of Mercury.* **P. Chappuis.** (Bureau Int. Poids et Mes., Mem. 16. [81 pp.] 1917.)—Callendar and Moss [Abs. 491 (1911)] determined the expansion of mercury over an interval of 310 deg. C.; their results, while in accordance at higher temperatures with those of Regnault, diverge more between 0° and 100° C., they also differ from those obtained by the author in 1890 by the relative method using the weight thermometer of *verre dur*, and Callendar has supposed that this divergence is due to the expansion of the glass envelope in the author's experiments being different in directions along and transverse to the axis of the tube. This is considered as very doubtful. The same tube of *verre dur* was also used in the determination of the expansion of water, and the values so obtained show remarkable agreement with those of Thiesen, Scheel, and Diesselhorst; also the results for the apparent expansion of mercury agree with those of Thiesen, Scheel, and Sell. Similarly with the determinations of Harlow and Eumorfopoulos. A new determination of the absolute expansion of mercury was therefore undertaken using apparatus very similar to that of Callendar and Moss.

The "hot" and "cold" columns are each composed of seven steel tubes of 1 m. length. The temperatures of the chambers containing the columns are measured by mercury thermometers placed at ¼ and ¾ their height. [For details of apparatus and precautions observed the original memoir must be consulted.] The horizontal connecting tubes first used were of 1 mm. diam., as in the experiments made by Callendar and Moss, but observations were difficult and precision diminished because equilibrium, attained by the flow of mercury in the tubes, required 10 mins. for establishment even for small variations of temperature. A new set of horizontal tubes of 1·4 mm. diam. was finally used, and the time for equilibrium after a small variation of temperature reduced to 4 mins. Mean coefficients for the expansion between 0° and 10°, 25°, 36°, 50°, 60°, 75° and 100° C. are given. Comparison with the results obtained by the author using the relative method, show that the mean coefficient (0° – 100° C.) found before is in close agreement but a little too great. The agreement with these experiments is much better than with those of Callendar and Moss. The author believes that the capacity of the chambers, their good thermal isolation and energetic stirring of the bath, permits a determination of the mean temperature of the columns to two or three hundredths of a degree and much more accurately than this at 100° C. For temperatures between 60° and 100° C. the divergences from Callendar and Moss correspond to an error of 0·25 deg. C. in the temperature, which is ten times the admissible error. The cause of the divergence cannot be surely indicated. The author insists upon the importance of perfect equilibrium between the hot and cold columns and suggests that Callendar and Moss's experiments should be repeated with a system of horizontal tubes of larger diameter. T. H.

1219. *Conduction of Heat in a Gas between Cylindrical Walls.* **K. Aichi.** (Phys.-Math. Soc. Japan, Proc. 1. pp. 164–178, June, 1919.)—Rayleigh has investigated the conduction of heat in a gas between two parallel planes, and when the gas is included in a spherical vessel whose walls are maintained at a constant temperature. The present paper deals with the case where the gas is contained between cylindrical walls, with more general boundary and initial conditions. A. W.

1220. *Specific Heats of Argon and some Polyatomic Gases.* **W. Heuse.** (Ann. d. Physik, 59. 1. pp. 86–94, June 18, 1919. From the Physikal.-Techn. Reichsanstalt.)—The present paper is the continuation of two earlier investigations on the specific heats of air, helium, and some diatomic gases [see Abs. 827 (1918)]. The method of continuous flow previously employed has been retained, full details of which have already been given [*loc. cit.*]. The measurements range from values at the room temperature to those in the vicinity of the condensation points of the respective gases which latter were: argon, carbon dioxide, nitrous oxide, nitric oxide, methane, acetylene, ethylene, and ethane. Section 2 of the paper contains details for the preparation of the gases whose purity was determined by spectrum analysis before and after each measurement. Nine tables of results are given.

H. H. Ho.

1221. *Latent Heat and Surface Energy.* **D. L. Hammick.** (Phil. Mag. 38. pp. 240–245, Aug., 1919.)—That the surface energy of a liquid and its latent heat must be intimately related has long been recognised, although apparently no attempt has up to the present been made to give the general relationship precision or to apply it to the data. In the present communication a definite connection between internal latent heat and surface is put forward, namely $\rho V/dJ = L_I/6$, where V is the gramme molecular volume of liquid, ρ the surface energy in ergs per cm.^{2}, d the molecular diameter, J the mechanical equivalent of heat, and L_I the internal latent heat per gm.-mol. in calories. This expression is shown to be in very fair agreement with the available data. Unfortunately, most of the latent-heat data refer to the boiling-point of the liquid, whereas measurements must be made at low temperatures to avoid a non-computable vapour surface-tension, and also to be in accordance with an assumption made as to the approximate contiguity of molecules. The molecular diameters have been obtained by taking the mean of the values calculated from measurements of various physical properties of the vapour, such as thermal conductivity, refractive index (or dielectric constant), etc. H. H. Ho.

1222. *Pressure of Saturated Steam.* **R. Hennig.** (Zeits. Vereines Deutsch. Ing. 63. p. 588, June 21, 1919.)—Discusses a suitable empirical formula for expressing the pressure of saturated water-vapour at various temperatures up to the critical point. J. W. T. W.

1223. *Vapour Pressure of Thin Films of Liquid.* **F. Michaud.** (Comptes Rendus, 168. pp. 1155–1157, June 10, 1919.)—The surface tension of a soap film is, after decreasing the thickness sufficiently, a function of the thickness of the film. It is likely that this fact is general, and that the surface tension of any pure liquid, stretched in a thin film, changes when the film thickness is of the order of the radius of molecular action. It is shown that the vapour pressure changes also. The author by taking such a film through a reversible isothermal cycle (1) stretching film, keeping thickness constant by condensing vapour upon it; (2) varying the thickness infinitesimally and returning to the initial state by reverse processes, calculates the change in vapour pressure for a change in the surface tension of the film, due to a change in its thickness. A similar calculation is also made for the case of one liquid stretched on the surface of another and it is shown that $\gamma_1 - \gamma_2 - \gamma_{12} = -(e\mathrm{RT}/\mu\mathrm{V}) \log (\mathrm{P}_1/\mathrm{P}_0)$, where γ_1, γ_2, γ_{12} are the surface tensions of supporting liquid, thin film in contact with vapour, thin film in contact with supporting liquid, respectively; e is film thickness, V the specific volume of the liquid of the film, R the gas constant, μ the molecular mass of the vapour, P_1 the vapour pressure when the film is at the max. extension, P_0 the normal value. Putting in values for oil on water we find that the vapour pressure of oil in thin films on the surface of water is only 1/5000 of the normal vapour pressure, $\mathrm{P}_1 = 2/5000$. The formula is also applied to a thin film stretched on a solid. Some experiments of Trouton on the absorption of water-vapour by glass-wool are discussed. Taking $e = 18{\cdot}4 \times 10^{-8}$ cm. it is found that $\gamma_1 - \gamma_{12}$, the difference between the surface tension of solid glass in contact with water-vapour and water respectively, is 12,400 dynes/cm. T. H.

1224. *Contribution to the Theory of Adiabatic Invariants.* **G. Krutkow.** (K. Akad. Amsterdam, Proc. 21. 8. pp. 1112–1123, 1919.)—Any quantity to be called a "quantum quantity" must satisfy two conditions: (1) it must be a function of the integrals of the equations of motion of the system under consideration; (2) it must be an adiabatic invariant, *i.e.*, be unalterable when the system is submitted to a reversible adiabatic influence. This demand was first formulated by Ehrenfest and proved on general statistical reasoning. There is still another condition which a quantum quantity has to satisfy: it must have a meaning which is independent of the system of coordinates. To the author this condition appears to embody the notion of the coherence of the degrees of freedom established by Planck. The present paper, however, deals with condition 2 only, which involves finding the adiabatic invariants of a given mechanical system, and seeking for a general method of solving the adiabatic problem.

The author sketches out a general method of finding adiabatic invariants, and then applies it to certain special cases—namely, cyclic systems, conditionally periodic systems, and ergodic systems. In the second of these systems only the limiting case is considered, in which there are no commensurable relations between the periodicity-moduli. The action dealing with the general method first defines adiabatic invariants, and then considers the isoparametric problem, the differential equations of the rheo-parametric problem, and the herpo-parametric or adiabatic problem. Two special problems, the linear oscillator and the rotating body about a fixed axis, are first treated by the general method before discussion of the general applications. H. H. Ho.

1225. *Further Remarks on the Electronic Vapour Problem.* **W. Schottky.** (Phys. Zeits. 20. pp. 220–228, May 15, 1919.)—In a previous note on electronic vapour pressure and the Clausius-Clapeyron equation, the author has shown that the formula recently given by M. v. Laue for the vapour density of electrons immediately at the surface of a conductor, does not deviate in essentials from the well-known formula for ordinary vapours deduced from the Clausius-Clapeyron equation and the gas laws. The recent work of v. Laue is fully discussed, together with the results of an independent investigation of the problem begun prior to the appearance of v. Laue's publication.

Section I deals with the electronic gas. The earlier view was that of a perfect gas in the gravitational field with the normal pressure and energy characteristics, but with the addition of an energy term with respect to the potential energy of the electrons in the external field. This view was recognised as valid by v. Laue, but with certain limitations which the present author now discusses. The conclusion drawn is that the electrons, above a certain density value dependent on the temperature, neither behave as a perfect gas nor as a cloud in the Laue sense, but that the average kinetic energy of a single electron deviates from that given by the Maxwell distribution law for a monatomic gas, and the Boltzmann *ε*-relation between density and average potential value ceases to apply. Another representation is therefore necessary.

Section II considers the field of the surface forces. Section III discusses the influence of structural effects and the force which gives rise to the electrons. Section IV investigates the quantitative conditions which obtain for the ideal gas state without and within the sphere of operation of the forces at the emission electrode. H. H. Ho.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1226. *The Fundamental Electromagnetic Equations in the Interior of Ponderable Matter derived from the Hamiltonian Principle.* **W. Dällenbach.** (Ann. d. Physik, 59. 1. pp. 28–32, June 13, 1919.)—In an earlier paper [see Abs. 928 (1919)] the general covariant equations of the electromagnetic field were obtained for the interior of ponderable matter from the equations in empty space; in the present paper they are derived from a Hamiltonian Principle in a similar manner to that used by Weyl for a vacuum [see Abs. 605 (1918)]. For simplicity the author adopts a system of coordinates, in which the special relativity equations hold good, but the transition to the general covariant equations is only a formal operation. The paper itself is mathematical throughout. H. H. Ho.

1227. *A Reciprocal Relation between certain Electrostatic Fields and Magnetic Fields of Corresponding Uniform Current.* **A. Gray.** (Phil. Mag. 37. pp. 472–480, May, 1919.)—Given a circular electrical distribution of line density ρ and radius a, and a point P in the plane of the circle, at a distance a' from its centre. Then it is shown that:—(1) If A be the intersection of the diameter of the circle through P, then the whole magnetic field intensity at A, due to a current $\rho a/a'$ in the concentric circle is numerically equal to the electric (or gravitational) field intensity at P due to the circle of radius a and uniform line density ρ; (2) The mutual inductance of two concentric coplanar circles is proportional to the electric (or gravitational) field intensity produced by a uniformly charged disc, the edge of which coincides with one circle, at a point on the circumference of the other; (3) The reciprocity (1) exists between a distribution of electricity on a plane conductor bounded by two close, similar, and similarly situated ellipses, and a uniform current in the confocal ellipse through the point considered. (1) is very simply extensible to the case of coaxial but non-coplanar circles. G. W. de T.

1228. *Electrification of Liquids by Spraying (Ballo-Electricity.* IV.). **C. Christiansen.** (Ann. d. Physik, 59. 1. pp. 95–100, June 13, 1919.)—Posthumous account of researches continued [see Abs. 468 and 842 (1913)] for the purpose of investigating whether isomeric organic compounds differ in ballo-electric power; the question remains undecided.

Aqueous solutions of the several tartaric acids are practically aballic, like inorganic acids; mixed with NaCl, they give the same high value as aqueous solutions of NaCl; mixed with alcohol, they again behave like mixtures of alcohol and NaCl. The same solutions gave, 9 months later, practically the same values as before, although then quite mouldy. Propionic acid is much more ballo-electric than the monochlor-acids, the α-acid being electropositive, the β-acid negative; the α-acid lost its power in the course of time; the specimens were prepared by A. Christensen, and chlorine ions were not present. Of the two oxybutyric acids, the β-acid has 16 times the ballo-electric power of the α-acid. The introduction of either chlorine or iodine into other organic compounds had no clear differential effect. H. B.

1229. *Streaming Metalic Vapour Arcs.* **E. Podszus.** (Zeits. Elektrochem. 22. pp. 179–181, June 1, 1917. Zeits. Instrumentenk. 39. pp. 38–39, Jan., 1919. Abs.)—The metallic vapour arc, so far studied only *in vacuo*, can be produced in the shape of a vapour stream flowing through the gas in a bulb as if confined by the surrounding gas. The kathode compartment is kept narrow in the form of a nozzle, from which the mercury vapour issues. To start the arc the anode is pushed down into the nozzle; the vapour is then forced out of the nozzle as a steady flowing column like an intensely-bright filament or rod. The electrodes proper are made of tungsten; electromagnetic starting devices have not answered. Several forms of apparatus are described. One type consists of an inverted flask, the short neck of which is closed below by an iron cap serving as tray for a little mercury. Through the iron base pass a gas supply pipe, the anode holder, in a quartz sheath, and the kathode, an iron tube ending inside in an insulating tube of boron nitride, to which the kathode, a piece of tungsten foil bent to a nozzle, is attached. The width of the luminous band is diminished by the gas pressure and increased by the current intensity; it is smaller in hydrogen than in nitrogen. The arrangement is suitable also for working with electrodes of the light metals, alloys and compounds; the latter are reduced to metal. At the anode a flame is seen; the colour of the arc depends upon the metal and the gas. Mercury gives a greenish-white arc in hydrogen and a bluish-white arc in nitrogen. The potential gradient was in hydrogen on 220-volt circuits, 8 volts per mm. with 10 amps. and 5 volts with 14 amps.; in nitrogen the gradient was 2·5 volts with 7·5 amps. The research was interrupted by the war. H. B.

DISCHARGE AND OSCILLATIONS.

1230. *Polarisation in the Geissler Discharge.* **E. Rumpf.** (Ann. d. Physik, 59. 1. pp. 1–27, June 13, 1919.)—A method is described by means of which a polarisation similar to that observed with electrolytes, has been demonstrated in the Geissler tube. It is found that in the metals Cu, Pb, Pd, Al and Pt-Ir, as well as in the discharge in air as also in hydrogen, a kind of polarisation is set up which depends very largely upon the surface condition of the materials mentioned, and less upon their chemical nature. The polarisation appearances depend on the tension, and exhibit a maximum which is conditioned by the previous treatment of the electrodes. The condition of the kathode has an especial influence on the polarisation. The magnitude of the back e.m.f. produced by polarisation could not be ascertained with the apparatus employed, but it was certainly generally in excess of 2 volts, the usual order of magnitude in electrolysis. The polarisation appearances are so much the smaller, the stronger the ionisation in the part of the tube under observation. It is concluded that the observed phenomena are to be explained by the formation of a gas skin at the kathode, thus forming a sort of condenser. A. E. G.

1231. *Some Characteristics of the Spark Discharge and its Effect in Igniting Explosive Mixtures.* **C. C. Paterson** and **N. R. Campbell.** (Phys. Soc., Proc. 31. pp. 168–227; Disc., 227–228, June, 1919.)—The first part of the paper deals with the nature of the spark discharge. Previous work on the subject is reviewed briefly, mention being made of the researches of Thornton and Wheeler in which, among other things, it is shown that energy is not the prime factor in determining the igniting power of a spark. Experiments were conducted to ascertain the relation between the electrical characteristics of spark discharges and their power to ignite explosive mixtures. An attempt was made to control the duration of the spark and the current passing. This, however, was unsuccessful as the discharge consisted of a series of discontinuous sparks which lasted for a period of time which could not be subdivided. Each spark consists of the passage across the gap of a definite quantity of electricity representing the discharge of a condenser of definite capacity, previously charged to the sparking voltage of the gap. The duration of a spark could not be definitely ascertained, but an upper limit was found Observations were also made of the discharge obtained from an induction coil. These are also characterised by the passage of a definite quantity of electricity across the gap. It is suggested that this quantity, together with the form of gap, may be sufficient to define the nature of the spark and to determine its igniting power.

The second part of the paper deals with the igniting power of the "capacity" spark. It is shown that discharges which consist of a series of similar sparks have the same igniting power as a single spark of the same nature; *i.e.*, ignition, if it occurs at all, occurs at the first spark. A number of experiments on the ignition of mixtures of petrol and air are described. The igniting power of a spark increases with both the capacity and the spark potential, but varies much more rapidly with the latter factor than with the former. The energy required for ignition decreases rapidly as the spark potential increases. If the spark potential were increased sufficiently, it is possible that the energy required for ignition might be reduced considerably below the lowest value obtained in these experiments, namely 4×10^{-4} joule.

Further experiments were conducted on mixtures of hydrogen and air. Indications of a phenomenon similar to the "stepped ignition" of Thornton were found. The cause of this phenomenon appears to lie in the qualities of the discharge rather than in those of the mixture.

An investigation was made into the influence of the form of the electrodes on the igniting power of the spark. With the same spark potential and capacity, the electrodes of smallest radius of curvature gave the greatest igniting power. The material of the electrode had no effect on ignition.

Measurements were made of the proportion of hydrogen burnt during an explosion. There is a distinction between mixtures which explode and those which merely ignite. The distinction is independent of the form of the igniting spark.

Experiments were conducted with an 8-cylinder aeroplane engine, using a magneto and a special arrangement consisting of a transformer, ionic valve, condenser, and high resistance. In this way it was found possible to supply a known amount of energy per spark. Using this arrangement, the amount of energy required to obtain the same power from the engine (with regular firing) was found to be $1{\cdot}4 \times 10^{-3}$ joule, or about 1/65th the energy given by the magneto. N. W. M.

1232. *Time Lag in the Spark Discharge.* **N. Campbell.** (Phil. Mag. 38. pp. 214–230, Aug., 1919.)—This paper is concerned with phenomena attendant on the sparking of gaps under different conditions. Reference is made to the question of the "impulse ratio" of a gap, this being the ratio of the potential required to produce a spark across a given gap with an oscillatory voltage and with a steady voltage. For "sphere gaps" the impulse ratio is unity, whereas for "needle" or "point" gaps it may be as large as 3 or 4. Peek explains the phenomena of impulse ratio by attributing a "time-lag" in the passage of the spark, *i.e.*, a finite time elapses between the attainment of the requisite sparking potential and the passage of the spark. In the magneto it is found that a point gap will *sometimes* spark at 7000 volts, but will not spark at *every* break of the current unless the potential is 12,000 volts. This indefiniteness is considerably reduced by using an auxiliary insulated point near the anode. Regular sparking is due to the ions produced by the pilot spark between the anode and the auxiliary point. A similar effect was found by using radium as an ionising agent. Experiments are described in which it is shown that the irregularity in sparking without the auxiliary point is due to a decrease in the casual ions present.

In sphere and other gaps where the sparking distance is small compared with the radii of curvature of the electrodes the impulse ratio is greater than unity. Some sparking plugs are found to be "hard," because they will not pass the oscillatory spark of a magneto although they have the same steady spark potential as other "soft" plugs which pass the magneto spark. The impulse ratio seems to vary with the pressure of the surrounding atmosphere and decreases with increase in pressure. "Hardness" is attributed to some condition of the surface of the kathode of the plug. A plug could be made hard by rubbing the kathode with fine, oily emery-cloth, and could thereafter be made soft by heating to redness. A freshly machined surface was usually soft. N. W. M.

1233. *The Light of the Hydrogen Canal-Rays.* **R. v. Hirsch.** (Ann. d. Physik, 59. 2. pp. 189–192, June 20, 1919.)—Vegard [see Abs. 497 (1917)] has doubted the correctness of the results previously published by the author because the variations in the ratio H_α/H_β are so small that they scarcely exceed the probable errors in measurement, while the ratio H_β/H_γ shows proportionately great differences. In the present paper these objections are dealt with, and the general question is discussed in the light of the more recently published results. A. E. G.

1234. *Distribution of Electric Force in the Crookes' Dark Space.* **U. Yoshida.** (Kyoto Coll. Sci., Mem. 3. pp. 183–187, Aug., 1918.)—The author determines the distribution of electric force in a hydrogen vacuum tube. The electrodes used are of aluminium, the diameters of the tubes vary from 3 mm. to 16 mm., and an induction coil is used as source of current. The method employed for the measurement of the intensity of electric force is to measure the amount of separation of the parallel and vertical components of the line H_γ by photographing the spectrum, using either a four- or five-prism spectrograph. The glow of the discharge in the dark space under the conditions used is concentrated into the axial portion of the tube and thus the intensities measured represent the values in the axial portion of the dark space.

The distribution is found to be represented by a parabolic equation of the form $E - E_0 = k(d_0 - d)^2$, where d_0 is the length of the dark space, E_0 the electric force at its end, d the distance from the kathode of a point in the dark space, and E the intensity at that point. k is a constant independent of d. E_0 is usually very small and put equal to zero. k decreases as the diam. of the tube and length of dark space increase, but increases with increase of current. The max. electric force, just in front of the kathode, decreases as the diam. of the tube increases, but increases with length of dark space and with the current. T. H.

1235. *The Audion as a Circuit Element.* **H. W. Nichols.** (Phys. Rev. 13. pp. 404–414, June, 1919.)—In this paper only those actions are considered which may be sufficiently well described by supposing the variations in anode and grid currents and voltages to be small. The methods adopted in a previous paper [Abs. 90 (1918)] are employed. The functional equations for the three-element audion are used to deduce the actions taking place in any circuit containing the audion. The equations for small variations in the general network containing audions are developed, and simple equivalent circuits to replace the tube are shown. The effects of the capacities between elements are next worked out, and also some examples of amplifiers and oscillation generators. A. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1236. *The Thermoelectric Equation* $P = T\,.\,dV/dT$. **E. H. Hall.** (Nat. Acad. Sci., Proc. 5. pp. 197–198, June, 1919.)—The validity of this equation is questioned by Hall, if P be taken as the ordinary Peltier-effect and V the Volta-effect between two metals. Kelvin regarded P as possibly including some other reversible heat effect accompanying movement of electric charge from one metal to another. O. W. Richardson in his derivation of the equation ("Emission of Electricity from Hot Bodies," p. 28) holds P to be simply the Peltier-effect. Richardson's equation $dS = (1/T)[d(nv\Phi) + p\,.\,dv]$ is correct when speaking of an insulated piece of metal which is imagined to give off electrons, but it is not applicable when an equal stream is entering by conduction. Making the necessary correction in Richardson's line of argument Bridgman arrives at Kelvin's result. L. L.

1237. *Peltier-effect, and Thermal and Electrical Conductivities of some Solid Metallic Solutions.* **E. Sedström.** (Ann. d. Physik, 59. 2. pp. 134–144, June 20, 1919.)—Borelius has formulated certain conclusions with respect to alloys of this class [Abs. 430 (1918)]. Rudolfi has found for some Au-Ag and Au-Cu alloys a catenary form for the curve expressing the relation between thermoelectric force and concentration. To extend the work further the author has used the apparatus of Borelius [Abs. 807 (1917), 1188 (1918)] to determine the various constants. The alloys examined were Au-Ag, Au-Cu, Au-Cd, Ag-Cd, Ag-Zn, Cu-Zn and Cu-Ni. The results obtained are exhibited in a series of tables and graphs in the paper. Speaking generally, the curves co-ordinating atomic percentage of metal and effect observed are of a catenary form, the chief departure being in the Cu-Ni alloys containing the higher percentages of Ni. L. L.

1238. *Thermal and Electrical Conductivities and Thermoelectric Power of Mercury in the Solid and Liquid States.* **G. Gehlhoff** and **F. Neumeier.** (Deutsch. Phys. Gesell., Verh. 21. pp. 201–217, May 30, 1919.)—The method adopted was a modification of that due to Lees [Abs. No. 1677 (1908)]. The constants could be determined for very small temperature differences. The Fig. gives a brief summary of the results contained in a series of tables and graphs in the paper. Λ is the thermal conductivity in c.g.s. units, κ the electrical conductivity in ohm^{-1} cm.$^{-1}$, and dE/dT the thermoelectric power against copper in micro-volts per deg. C. The Fig. shows the abrupt change in these quantities on passing from the solid to the liquid state. The thermal conductivity is diminished in the ratio of 1 : 3, the electrical conductivity in the ratio of 1 : 3·8, while the thermoelectric force increases from about 0·4 to 3·5 microvolts in passing from the solid to the liquid. The Wiedemann-Franz ratio Λ/κ and the Lorenz ratio $\Lambda/\kappa\tau$ (τ = abs. temperature) are also calculated. The authors point out that the ratio of the thermoelectric power to the Wiedemann-Franz ratio is approximately constant although the numerical value differs for the two states, 1·4 for the solid state and 2·6 for the liquid. The results are considered from the point of view of the mechanism of conduction in the solid and liquid states. The authors conclude that the material plays the most important part in conduction, and

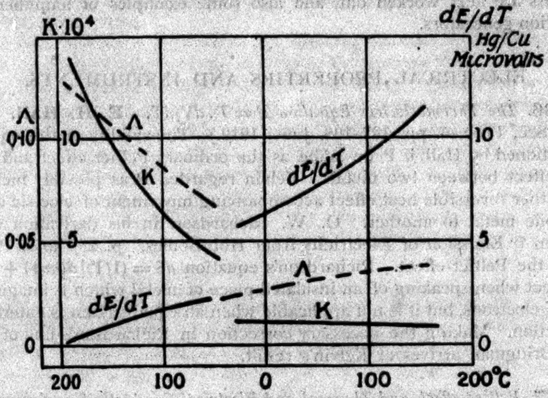

FIG. I.

that the increase of thermal conductivity with temperature in the liquid state is due to dissociation. The behaviour of the thermoelectric property is, however, opposed to this. It would be necessary either to assume that in liquid metals the concentration of electrons diminishes with increase of temperature, or that concentration and pressure are not proportional to one another. Errata (*Ibid.*, p. 388, June 30, 1919). L. L.

1239. *Galvanometry*. **D. Germani.** (Rev. Gén. d'Él. 6. pp. 99–101, July 26, 1919.)—Starting from the formulæ established by Chaumat for the aperiodic and periodic motions of a moving-coil galvanometer, a curve is constructed which gives the value of the ballistic constant as a function of the resistance of the galvanometer circuit. From this curve the author then deduces the optimum value of the circuit resistance for the measurement of inductive discharges. It is found that the value of optimum circuit resistance is further below the critical resistance the greater the damping due to the air, the optimum and critical resistances being coincident for zero air-damping. The curve here used may be called the characteristic curve of the galvanometer; near the origin it exhibits a point of inflection. A. W.

ALTERNATING CURRENTS AND MAGNETISM.

1240. *Some Physical Constants of Iron-Cobalt Alloys.* **K. Honda.** (Tôhoku Univ. Sci. Reports, 8. pp. 51–58, April, 1919. Twenty-sixth Report of the Alloys Research Inst.)—In a previous paper the author has given the results of investigations on the thermal and electrical conductivities of some Ni steels and also the magnetisation curves of these alloys [Abs. 1190 (1918)]. Similar investigations have now been carried out on some alloys of Fe and Co which form a continuous series of solid solutions of these elements. Fig. 1 shows the thermal (κ) and electrical (σ) conductivities plotted against the composition of the alloy. The elasticity (E) and the rigidity (K) were also measured; the results are represented graphically in the original. Data are given in the paper for the magnetisation curves for these alloys. They are of form similar to that for pure iron. Fig. 2 shows the magnetisation-concentration curve in a field of 1200 gauss. The maximum at about 35 % Co agrees with that found by A. Preuss. The max. value is considerably

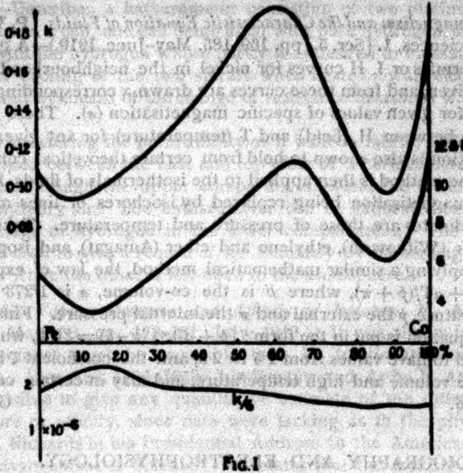

FIG. 1

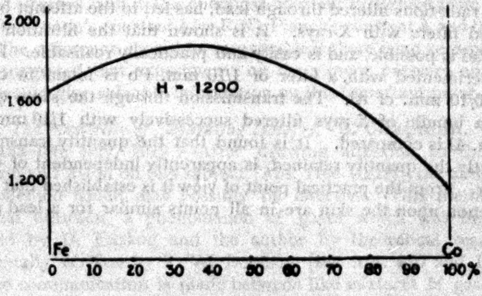

FIG. 2.

greater than that of its components. As the system Fe-Co forms a continuous series of solid solutions and no compound is formed the saturation values should obey the addition law. The author considers the saturation value of magnetisation for iron to be above 2200, and not 1700 as generally accepted.

L. L.

1241. *Ferromagnetism and the Characteristic Equation of Fluids.* **P. Weiss.** (Archives des Sciences, 1. [Ser. 5.] pp. 169–185, May–June, 1919.)—A group of magnetic isothermals or I, H curves for nickel in the neighbourhood of the Curie point is given, and from these curves are drawn a corresponding group of H, T curves for given values of specific magnetisation (σ). These exhibit a linear relation between H (field) and T (temperature) for any given value of σ. This relation is also shown to hold from certain theoretical considerations. The same method is then applied to the isothermals of fluids, lines of equal specific magnetisation being replaced by isochores or lines of equal volume; the ordinates are those of pressure and temperature. Taking the isochores for air (Witkowski), ethylene and ether (Amagat), and isopentane (Young), and applying a similar mathematical method, the law of expansion found is $v = b + aT/(p + \pi)$, where b is the co-volume, a is 1/273·1, T is absolute temperature, p the external and π the internal pressure. Finally the characteristic equation is put in the form: $(p + a/v^{\eta})(v - b) = \zeta RT$, where the power η is found to have values from 1·5 to 2·5, and the coefficient ζ has the value 1 for large volume and high temperature, and may in certain cases be greater than 2·65.

G. E. A.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

1242. *Lead as a Filter in Radio-Therapy.* **Dissez.** (Archives d'El. Médicale, 27. pp. 137–139, May, 1919.)—The necessity for employing very penetrating X-rays in the treatment of deep-seated or extensive tumours and in all cases where very hard rays are preferable to rays of medium hardness, and the fact that in this case the preference is often given to the employment of radium radiations filtered through lead, has led to the attempt being made to use lead filters with X-rays. It is shown that the filtration of X-rays through lead is possible, and is easily and practically realisable. In the condition experimented with, a filter of 1/10 mm. Pb is found to correspond to one 100/10 mm. of Al. The transmission through the same quantity of water of a bundle of X-rays filtered successively with 1/10 mm. Pb and 100/10 mm. Al is compared. It is found that the quantity transmitted, and consequently the quantity retained, is apparently independent of the nature of the filter. From the practical point of view it is established that the results and the action upon the skin are in all points similar for a lead and for an Al filter.

A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1243. *Measuring the Purity of Hydrogen.* (El. Rev. 85. pp. 59–60. July 11, 1919.)—Describes a katharometer consisting of two platinum spirals, each enclosed in a cell, one cell being filled with pure hydrogen, while the other is filled with the hydrogen whose purity it is desired to measure. The relative rates of cooling of the two spirals when heated by an electric current are compared by means of the change of resistance measured with a Wheatstone bridge.

For measuring the permeability of a balloon fabric, a piece of the fabric is clamped between the base and top plate of a permeameter, and hydrogen is passed through the upper compartment, while the lower compartment is filled with dry air. The katharometer can be calibrated to give directly the percentage of hydrogen in the lower compartment. The instrument may also be used to give a record of air humidity by immersing one coil in pure dry air while the other is left open to the atmosphere. J. W. T. W.

1244. *Vapour Pressure and Affinity of Isotopes.* **F. A. Lindemann.** (Phil. Mag. 38. pp. 173–181, July, 1919.)—It was shown in a recent paper that isotopes must be separable both by fractionation and by chemical means. [See Abs. 1106 (1919), Lindemann and Aston.] At that time it was not possible to give any quantitative estimate of the differences in vapour pressure or affinity, since data were lacking as to the physical properties. T. W. Richards in his Presidential Address to the American Association for the Advancement of Science (1918) states that the melting-points of the two sorts of lead of atomic weight 207·19 and 206·34 have been found to be identical within the limits of experimental error. This information has enabled the author to repair the omission in the previous paper referred to above. In his summary the author concludes that although isotopes cannot be identical chemically there is only a second-order difference if "zero-point energy" is assumed, and if the chemical constant is derived from the atomic mass m, Boltzmann's constant k ($=R/N$), Planck's constant h, and the temperature θ. The difference should be measurable if there is no zero-point energy, and it is suggested that experiments on the vapour pressure and affinity of isotopes would give valuable information on this important point. A. B. W.

1245. *The Possibility of Separating Isotopes.* **S. Chapman.** (Phil. Mag. 38. pp. 182–186, July, 1919.)—After drawing attention to the paper by Lindemann and Aston on this subject [Abs. 1106 (1919)], the author suggests a novel method which may possibly be effective. This method depends on thermal diffusion, a phenomenon of gases which was independently discovered by D. Enskog and the author by theoretical reasoning, and experimentally verified by F. W. Dootson [see Abs. 970 and 1152 (1917)].

If free communication is made between like mixtures of gases in vessels maintained at different temperatures, diffusion will take place until an equilibrium condition is reached in which there is a slight excess of the heavier gas in the cold vessel, and of the lighter gas in the hot vessel. If the molecular masses are equal but the diameters unequal, the larger molecules will be in excess in the cold vessel. The question is considered mathematically, and the author concludes that thermal diffusion, many times repeated, should prove a practicable method of separating isotopes of the kind considered. A. B. W.

1246. *The Development of Crystals.* **R. Marcelin.** (Annal. de Physique, [ix] 10. pp. 185–188, Sept.–Oct., 1918.)—Observing crystal development in an alcoholic solution of *para*-toluidine under the microscope, the author (killed in the war) finds that the crystals grow by successive deposition of uniform layers arranged in steps which first appear grey and then coloured; the minimum thickness observed of 1·6 and 2·5 $\mu\mu$ would correspond to 8 molecular diameters. Finally the tint becomes quite uniform. In these experiments the illuminating rays are filtered through alum solution to absorb the heat rays. When the alum cell is removed, the crystal begins to re-dissolve, and in this process the solid again disappears in layers of definite thickness. It would appear that a solid crystalline structure does not require a thickness of more than 20 molecules, and this limit is probably too high. H. B.

1247. *Metallographic Study of Tinplate.* **L. Mayer.** (Stahl and Eisen, 38. pp. 960–962, Oct. 17, 1918.)—There is no proof that iron dipped into molten tin really alloys with the tin, and the time of the ordinary process is too short to admit of diffusion of the tin into the iron. The author left small blocks of three irons (electrolytic, 0·02 % C., 0·41 % C.) in the tin bath for ½ hour at 300, 500, 750, 950 ° C. At 300° the pearlite and ferrite remained unaffected, but an intermediate bluish crystalline zone developed between the tin and iron; at higher temperatures the intermediate layer grew, and the pearlite seemed to be pushed down into the iron; finally there was no clear tin layer left, but the whole was a mixture of white and bluish crystals; the carbon percentage affected the temperatures at which the appearance changed. The 8 plates of photographs always show a sharp demarcation line between the tin and iron. H. B.

1248. *Molecular Condition of Alloys in the Crystalline State, and the Equilibrium Diagram.* **G. Masing.** (Internat. Zeits. Metallogr. 9. pp. 21–37, Nov., 1916.)—Dissociation in the solid state is, for the concentration range of mixed crystals, not incompatible with the general crystalline conception. An alloy, which is largely dissociated in the solid state and not capable of taking up more than small quantities of the components in solid solution, can as an independent entity exert that solvent power only over a small temperature range in the neighbourhood of its melting-point; for instance, a dissociated compound capable of forming mixed crystals with its own components over a wide temperature range will likewise be able to yield homogeneous mixed crystals over a large concentration range. When, however, a compound, stable over a large temperature range, has a very limiled miscibility, it cannot be more than slightly dissociated. Hence the equilibrium diagram enables us to draw conclusions as to the molecular shape of an alloy, but an extensive range of solubility in the solid state does not necessarily imply extensive dissociation. When compounds are highly dissociated, the maxima or minima of the thermal or electric conductivity curves, etc., indicate the existence of compounds which need not, however, correspond to the composition of the compound.

There is no symmetrical relation between the curves of solubility and homogeneous equilibrium. H. B.

1249. *High-temperature Investigations.* X. *Chromium and Carbon.* **O. Ruff** and **T. Foehr.** (Zeits. Anorg. Chem. 104. pp. 27–46, Aug. 18, 1918.)—To prepare alloys saturated with carbon the chromium (by the thermit process) is fused in a carbon crucible and stirred with a carbon rod, being kept up to 2800° (2657° max.) for 15 minutes, when it takes up 14·18 % C. For the lower alloys chromium is fused with an 11·6 % C. alloy in a magnesia crucible at 1850° ; the Cr and alloys attack the magnesia at higher temperatures, and crucibles of alumina or of zirconia are not preferable in this respect. Two groups of alloys may be distinguished : (1) Alloys with 8·5 % carbon, quite soluble in HCl of 24 %, and (2) alloys richer in carbon, partly soluble. From (1) Cr may be extracted by HCl, leaving Cr_5C_2 as residue, a carbide of m.p. 1605°, density 6·915, forming silvery crystals which are not attacked by aqua regia and not decomposed by fusion. Moissan's Cr_4C could not be traced. The alloys (2) are coarser ; supersaturated at the highest temperatures they contain up to 23·1 C. ; the HCl apparently extracts a carbide Cr_4C_2 (not isolated) ; there is no free chromium, only carbide and graphite. The insoluble residue consists of Cr_3C_2 and graphite ; this carbide Cr_3C_2, density 6·683, melts at 1890°, reduces when fused the crucible materials mentioned, and is decomposed by chlorine at red heat. There may be a further carbide CrC. When the alloy saturated with carbon is boiled at 2570° and a pressure of 8 to 14 mm. Hg, pure chromium vapour is evolved.

An equilibrium diagram is given. H. B.

1250. *Fusion and Crystallisation of Iron-carbon Alloys.* **R. Ruer** and **F. Goerens**. (Ferrum, 14. pp. 161–177, Aug.–Sept., 1917.)—Pure electrolytic iron is fused, in porcelain tubes heated in an electric furnace in a nitrogen atmosphere, with sugar carbon so as to produce iron containing from 0 up to 4·2 % of carbon, for the purpose of further investigating certain parts of the Fe-C equilibrium diagram. The melting and solidification points (commencement of crystallisation) give for the cementite eutectic the mean temperature of 1145°, the eutectic containing 4·2 % C, the graphite eutectic gives 1152° and 4·15 % C ; the pearlite point is at 721° with 0·9 % C. The conclusion is confirmed that the graphite separates as such from the liquid phase and is not formed by the disintegration of any carbon compounds preformed. The paper concludes with a summary of the results of this paper and of previous work of Ruer and Goerens, and Ilyine with special regard to freezing-point curves. H. B.

1251. *Effect of Time and Low Temperature on Physical Properties of Medium Carbon Steel.* **G. A. Reinhardt** and **H. L. Cutler**. (Am. Inst. Mining Eng., Bull. No. 151. pp. 1091–1098, July, 1919.)—Gives the results of experiments carried out to determine the effect of resting and low-temperature heating on the mechanical tests of test-pieces obtained from blooms. The investigation was undertaken owing to the fact that higher elongations were obtained from test-pieces prepared the day before breaking than from test-pieces broken the same day. Many results are given which indicate that the poor elongation of the tests made immediately after machining is not due to the machining operation to any great extent. The ductility of the blooms is greatly improved, however, by some equilibrium adjustment which takes place slowly at room temperatures and much more rapidly at slightly increased temperature, say 120° C. Differences are noticed between the results obtained on tests from blooms and from small billets, and these are probably due to a combination of solidification and rolling strains. C. O. B.

1252. *Heat-treatment of Grey Cast Iron at Low Temperatures.* **J. E. Hurst**. (Engineering, 108. pp. 1–3, July 4, 1919.)—The loss of strength and increase of volume experienced by cast iron when heated to temperatures below the lowest critical point are shown to be due, in part, at any rate, to the decomposition of the iron carbide with precipitation of graphite. This low-temperature graphitisation occurs only when silicon is present. The main results of experiments carried out on ¾-in. square bars which were heated for 150 hours at 575° C. are given below.

Composition.						Brinell hardness.		Impact value (ft. lbs.).	
Before treatment.				After treatment.		Before.	After.	Before.	After.
C.C.	Gr.	Si.	Mn.	C.C.	Gr.				
0·78	2·75	1·14	0·31	0·54	3·02	212	207	6.0	8·0
0·75	2·69	1·47	0·50	0·70	2·78	228	207	6·0	10·0
0·62	2·74	1·58	1·02	0·50	2·88	255	217	4·75	5·0
0·38	2·66	2·69	0·33	0·10	3·06	179	196	4·75	9·0

The effect of this heat treatment was to lower the tensile strength from 16 to 13·9 tons per sq. in. An average increase of 0·35 % in length was effected as a result of the graphite precipitation.

A good summary of previous work is included. F. C. T.

1253. *Solid and Liquid States of Steel.* **C. Johns.** (Engineering, 107. pp. 721–722, May, 30, 1919. Lecture delivered to the W. of Scotland Iron and Steel Inst., Dec. 2, 1918.)—There are only three states of matter, the "amorphous" state, to which references abound in literature, being only a modification of the solid or liquid forms or possibly of both. Iron has a considerable vapour pressure at the temperature of the open-hearth furnace, and the vapour exercises a considerable influence on the reactions taking place during the manufacture of steel. Steel is defined as "iron to which appreciable quantities of some element or elements have been added during manufacture for the specific purpose of modifying or adding to its desirable properties." A solid is defined as a crystalline aggregate, and since a crystal is a body whose atoms are oriented according to a definite system the change from the solid to the liquid state is brought about by the loss of orientation caused by the application of heat. If the resulting body still possesses considerable rigidity and is unable to flow under the action of gravity it is usually described as amorphous, but Beilby's term "vitreous" is a better one. A stream of molten steel radiates less heat than a stream of slag. At the moment of solidification there is a marked rise in the intensity of the heat radiated owing to the surface becoming coated with a layer of oxide. The surface of the molten steel reflects light like a polished solid metallic surface, because it is preserved by an atmosphere of iron vapour. Liquid steel has a surface tension comparable with that of mercury; but on account of the high temperatures involved, experimental determination is difficult. Skin effects of steel which has solidified out of contact with the atmosphere are due to surface tension which overcomes the directive forces of crystallisation, and maintains the skin in the vitreous state. The value of the surface tension increases with the volume of occluded gases. This is attributed to the presence of iron oxide dissolved in the steel, the elimination of which increases the surface tension and decreases the volume of occluded gases.

Hydrostatic pressure raises the melting-points of all materials except water, gallium, and bismuth, in accordance with the general rule that uniform pressure opposes change involving an increase in volume and assists changes involving a decrease in volume. The hardening of steel is discussed from this point of view.

Non-uniform pressure sets up shearing stresses, gives rise to the conversion of part of the material to the vitrified state and lowers the melting-point. F. C. A. H. L.

1254. *Use of Optical Pyrometers for Control of Optical-glass Furnaces.* **C. N. Fenner.** (Am. Inst. Mining Eng., Bull. No. 151. pp. 1001–1011, July, 1919. Engineering, 108. pp. 256–257, Aug. 22, 1919.)—Gives an account of the experiences of the staff of the Geophysical Laboratory in the control of the temperature of industrial furnaces employed for the manufacture of optical glass. The disappearing filament type of optical pyrometer was found to be more reliable than thermo-elements. The conditions which must be observed in practice to obtain reliable results are set out. E. G.

1255. *A Method of Growing Large Perfect Crystals from Solution.* **R. W. Moore.** (Am. Chem. Soc., J. 41. pp. 1060–1066, July, 1919.)—In the course of an investigation of some of the electrical properties of crystals, it became necessary to procure large pieces of wholly clear Rochelle salt crystals. It was found impractical to obtain these from commercial sources; a search through tons of crystals yielded only one or two pounds of suitable material. The author thus found it necessary to work out a laboratory method for the production of large crystals, and this forms the subject of the present paper.

Previous work on growing crystals by Krüger and Fink, Valeton, Hostetter, and Blake is first described. The practice adopted for the production of large crystals of Rochelle salt is then outlined as follows:—A saturated solution is made up at some convenient temperature, usually between 35° and 40°, removed from the excess of salt, heated to a temperature about 7–8 deg. above the saturation temperature, and filtered through paper on a Büchner funnel. The temperature of the solution is not allowed to fall to less than 4–5 deg. above its saturation temperature. Small seed crystals are placed in a jar and the salt solution then poured in. The jar is covered at once with a glass plate and placed in a large water-bath, the temperature of which is about 0·5 deg. above the saturation temperature of the solution. The temperature of the whole is allowed to fall off to practically the saturation temperature as fast as the bath tends to cool. Then, by means of a sensitive thermostat, the rate of cooling is controlled and the temperature allowed to drop at the rate of about 0·1 deg. per day, until the crystals have increased noticeably in size and have built out into perfect crystals. This usually takes only about one day after the saturation temperature is reached. Then the temperature is allowed to fall about 0·2 deg. per day; after the crystals are about ¾ to 1 in. long, the rate of cooling is increased to 0·3 deg. to 0·4 deg. per day, and when the crystals are well over one inch, to 0·5°–0·6° per day. The thermostat setting is changed twice each day—morning and evening. When the solution has cooled to about room temperature, the jar is removed from the bath and the crystals are taken out. They are dried by wiping with a soft, dry cloth. The temperature-saturation curve must be plotted in order to know exactly at what temperature the solution used will begin to crystallise. Seed crystals are discussed, the size used being about 5 mm. long and 2 mm. thick. Details of the precautions to be observed are given at some length. The apparatus, including water-baths, thermostat, etc., is adequately described with discussion as to rate of growth, temperature of saturation, etc. The difficulties encountered in washing the crystals are referred to in conclusion. The author opines that his method should be applicable to many substances which crystallise from solution either in water or various other solvents, and which have a considerable variation in solubility with change of temperature.

H. H. Ho.

1256. *Theory of Solubility.* **A. Colson.** (Comptes Rendus, 168. pp. 681–684, March 31, 1919.)—From different standpoints the principles of thermodynamics [see Abs. 1177 (1916)] have led to a rational formula which expresses all the characteristics of solubility, *e.g.*, sense of the phenomenon, angular points, eutectics, etc. Experiment shows that the concentration C of a solution expressed as a percentage of anhydrous salt in a saturated solution at T°, varies in the same sense as the osmotic pressure p, and this condition is expressed by the equation $i \, . \, dC/dT = dp/dT$, i being a coefficient ≥ 1; the rational solubility formula then becomes: $425 \times L = T(V + \epsilon) \, i \, . \, dC/dT$. The comparison of the dissolved body with saturated vapours is no longer involved, although the solvent increases by unity the variance of the system undergoing transformation; this previous defect disappears in the new formula where the work of transformation at T°, measured by the heat of saturation L, is connected not only with the contraction ϵ of the final system as in every change of state, but also with the volume V of solvent which saturates the dissolved molecule. The importance of this new variable V is considerable, because this quantity (always positive and superior to the contraction ϵ) characterises the solubility of a definite body such as $Na_2SO_4 . 7H_2O$, whereas the concentration or weight of anhydrous salt may correspond to various degrees of hydration. In the case of the solubility of a defined salt, the course of the phenomena, according to the formula, is governed by the heat of saturation L, and the concentration therefore increases with T if L is positive and decreases when L is negative. A maximum of solubility corresponds to $L = 0$, and occurs exclusively with definite compounds which dissolve and separate in the same state, *e.g.*, gypsum, calcium hydrate, etc. Otherwise, isomerism or hydration of the dissolved body gives rise to abrupt changes shown by angular points on the concentration curve $C = f(T)$. Such an angular point is due to the intersection of the two concentration curves of the original and new bodies respectively, and marks the transition from the solubility of one to the other. It, however, corresponds neither to a maximum nor to a minimum of saturation if the heat of saturation does not change sign. Examples are quoted of common salt and sodium formate. The problem of max. solubility is briefly discussed in the concluding paragraph.

Erratum. (*Ibid.* p. 1168, June 10, 1919.) H. H. Ho

1257. *Solubility.* III. *Relative Values of Internal Pressures and their Practical Application.* **J. H. Hildebrand.** (Am. Chem. Soc., J. 41. pp. 1067–1080, July, 1919.)—In a previous paper [Abs. 270 (1917)] the author showed that deviations from Raoult's law for non-polar substances could be predicted on the basis of differences in internal pressures of cohesions of substances in the liquid state. Since, in systems where it is obeyed, Raoult's law furnishes a method for calculating solubilities of both solids and gases, the prediction of deviations from it makes possible the estimation of relative solubilities. Moreover, deviations from a number of fundamental physico-chemical formulæ such as those dealing with molecular weights of dissolved substances, osmotic pressure, Henry's law, the distillation of liquid mixtures, and concentration cells, are more readily understood thereby. The present theory presents a method of approach to the various problems involving the colligative properties of solutions, concentrated as well as dilute, and postulates that (1) with non-polar substances Raoult's law will be obeyed by mixtures of liquids having equal internal or cohesive pressures, and (2) the greater the difference between the internal pressures the greater will be the escaping tendency of each component of the mixture, and hence the greater the positive deviation of both components from Raoult's law. How this theory could be used to predict solubilities was explained in the first paper, but a most unsatisfactory feature consisted in the divergent values of the internal pressures as calculated by other workers, and the uncertainty involved in any attempt to deal with substances other than those in the given tables. A careful critique of the whole subject is thus necessary, and as a preliminary result the author has calculated from very simple data by several independent methods the position of each substance in a table of relative internal pressures.

Section 2 deals with methods for calculating internal pressure, *e.g.*, surface tension, heat of vaporisation, critical data, and from these the coefficients of expansion and compressibility; a comparison of values obtained by these different methods is given in two tables. Relative internal pressures at — 203° C. are also included.

Section 3 discusses the use of the table of relative internal pressures, and comprises solubility precautions for solids, liquids, and gases, distillation of liquid mixtures, molecular weights and association, deviations from the mass law, partition coefficients, and recrystallisation. While the values of the internal pressure of liquids as obtained by independent methods differ considerably, they are found to be closely parallel. A later paper is promised to deal more fully with the theoretical aspects of the problem, since the present publication presents only a practical basis for predicting solubilities and for dealing with other problems which may be connected with deviations from Raoult's law. H. H. Ho.

1258. *An Electromagnetic Hypothesis of the Kinetics of Heterogeneous Equilibrium, and of the Structure of Liquids.* **W. D. Harkins.** (Nat. Acad. Sci., Proc. 5. pp. 152–159, May, 1919.)—While Gibbs has given a very broad treatment of "the equilibrium of heterogeneous substances" from the thermodynamic standpoint, nothing is included which would give any idea of the probable distribution of a component between a set of phases from a knowledge of the properties of only the pure component and of those of the phases before any of this component has been added to them. The purpose of this paper is to indicate that the general nature of such a distribution can be predicted in most cases from the standpoint of the hypothesis that it is determined mainly by the intensity and nature of the electromagnetic field surrounding the molecules, and by the motion of the molecules and atoms. The greatest obstacle is the meagreness of data with respect to the characteristics of this field, which is designated the "stray field" of the molecule, since it gets out beyond the electronic constituents of the molecule. The first problem considered is:—Given 2 components, each in a phase by itself and both phases in the liquid state at a common temperature, when will these two phases be miscible and when will they be practically insoluble in each other? A list is given of substances in the order of intensity of the stray electromagnetic fields, which also shows the substances in increasing order of cohesion. A low stray field is found when, according to the theory of Lewis, the atomic or molecular outer shell of electrons is complete; the highest stray field, when the shell is half-filled, *i.e.*, when there is the possibility of the greatest number of electronic leakages directly between the atoms, without the intermediate formation of molecules of a simple type containing only a few atoms. Accompanying a high field the substance is found to have a low atomic volume, a high cohesion, a high melting-point, a low coefficient of expansion, a low compressibility, etc. When the field is low in intensity, the properties are just the opposite. In its application to pure liquids, the theory shows that liquids of like cohesions are miscible while those whose cohesions are very unlike are practically insoluble in each other. The theory is next applied to interfaces and to distribution between regions. Experimental work is quoted in support of the theory to show that corresponding to the greater drop in intensity of the stray field between metal and vapour, in comparison with that between water and vapour, the adsorption at the metallic surface is much greater than that at a water surface for the same concentration of the adsorbed component in the non-metallic phase. When applied to the structure of a liquid, the hypothesis indicates that when the molecules are not wholly symmetrical there will be more or less grouping of the parts of the molecules around which the stray field is the most intense, the extent of the grouping being a function of the temperature also. If molecules of the polar-non-polar type are dissolved in a non-polar liquid this grouping is commonly spoken of as associate of the solute; in a polar solvent it is considered as the solvation or hydration of the solute, in pure liquids it is designated as the association of the liquid. These groupings are constantly being modified by the kinetic agitation, the other factors being the intensity of the stray field, and the space available for the grouping. H. H. Ho.

1259. *Galvanic Potential of Alloys.* **G. Tammann.** (Gesell. Wiss. Göttingen, Nachr. pp. 345–372, Dec. 21, 1917. Chem. Zentralbl. ii. pp. 265–267, 1918.)—There are limits in the galvanic polarisation of alloys analogous to their resistance limits. Conclusions may be drawn from the potential at which the less noble metal of an alloy passes into solution as to the state in which that metal exists in the mixed crystal. It is desirable to extend the study of the connection between the potential of an alloy and its composition, because the thermodynamic theory of potentials does not admit of such galvanic resistance limits. The alloys studied are those of Ag-Au and Ag-Zn, the former in various couples (with silver nitrate and gold chloride) and also in cells in which glass at 320° separates the silver and alkali nitrates. The change in the potential at the resistance limit indicates whether the two kinds of atoms may be considered as free or as partly bound in the space-lattice. H. B.

1260. *The Adsorption Isotherm at Low Concentrations.* **A. M. Williams.** (Roy. Soc. Edinburgh, Proc. 39. pp. 48–55, 1918–1919.)—Several formulæ have been proposed to express the adsorption equilibrium between the amount absorbed a and the equilibrium concentration c. That most extensively employed was apparently first used by Küster, and is based on the increasing positive adsorption of the first portion of the (c, α) curve in the case of solutions. The graph of $(\log c, \log \alpha)$ is found to be approximately a straight line with a gradient <1, hence $\log \alpha = \log \alpha_0 + 1/n \,.\, \log c$ or $\alpha = \alpha_0 c^{1/n}$. For gases, p usually replaces c in the formula. If, however, the $(\log p, \log \alpha)$ curve for any individual temperature be examined, it will be found distinctly concave to the $\log p$ axis, the gradient increasing as α decreases. Since hydrogen is, of the gases ordinarily examined, the least adsorbed at any given temperature, this gas is most likely to furnish evidence as to the nature of the adsorption isotherm in the region of low values of α. This gives $\alpha = \alpha_0 p$ at low pressures, the value of $1/n$ being unity at ordinary temperatures, while as the pressure rises, there is a distinct fall in its value. For small values of α, however, the adsorption law appears to be $\alpha = \alpha_0 c$ for both gases and solutions. Observations are quoted on the adsorption at 25° C. of hydrochloric acid from aqueous solution by blood charcoal. The general form of the adsorption curve for solutions is deduced from the above conclusion, and found to agree with the results of different observers. H. H. Ho.

1261. *Electrochemical Behaviour of Molybdenum and its Compounds.* **K. Wolf.** (Dissertation, Aachen, [88 pp.] 1917. Chem. Zentralbl. i. pp. 608–609, 1918.)—Pure molybdenum can be obtained from commercial metal by heating it up to 2250° for 6 hours in a current of hydrogen, and can be formed into sticks without the application of pressure. The chief difficulty is the exclusion of oxygen. With chlorine the metal forms the black deliquescent pentachloride $MoCl_5$, which, at 250° in hydrogen, turns into the brownish-red amorphous $MoCl_3$; the latter, heated in CO_2, is converted into the volatile tetrachloride, and the amorphous pale-yellow dichloride $MoCl_2$. The dichloride, however, must not be heated in the presence of air, in which it would turn into black oxide and a white, wooly sublimate. Analytically molybdenum can be determined as hydrated sesquioxide, which at first shows a pseudo-metallic conductivity; this separation would not answer technically, as the yield is very poor. In the potential series Mo stands between mercurous Hg and tervalent Sb. The metal freezes at 2250°. H. B.

1262. *Electrolytic Production of Fluorine.* **W. L. Argo, F. C. Mathers, B. Humiston,** and **C. O. Anderson.** (J. Phys. Chem. 23. pp. 348–355, May, 1919.)—Details are given of an apparatus for the preparation of fluorine by the electrolysis of fused potassium hydrogen fluoride at a temperature of 225°–250°. The copper electrolysing cell serves as kathode, the anode being made of graphite; Pt anodes could not be used as they were attacked badly. Various tests for fluorine are given, and it is stated that with the apparatus described the properties of fluorine can be shown as a regular lecture experiment involving no special difficulties. T. S. P.

1263. *Back E.M.F. of Polarisation in Sulphuric Acid.* **A. Noyes.** (Comptes Rendus, 168. pp. 1049–1052, May 26, 1919.)—The back e.m.f. of polarisation of a solution is the minimum potential at which electrolysis of the solution is produced. From the theoretical standpoint, when two electrodes are placed in a solution, and a difference of potential is established between them which increases regularly, no current should pass until the minimum potential necessary for the electrolysis of the solution has been attained. In practice, however, the presence of certain impurities cannot be avoided, and this permits the passage of a feeble current prior to the minimum potential being attained. This parasitic current slowly increases with the potential difference, but from the moment where chemical decomposition commences, the growth is much accelerated. In the course of experiments upon the electrolytic deposition of iron, the variation of this back e.m.f. with temperature was investigated. Having established that the back e.m.f. observed in solutions of iron salts diminished considerably at higher temperatures, and that in addition the curve of current intensity presents two angular points as against the one hitherto known, the author opines that one of these angular points corresponds to the back e.m.f. of the sulphuric acid. A full description is given of the apparatus used and the experimental data employed. The sulphuric acid was obtained by adding 100 cm.^{3} of chemically pure acid to 1500 cm.^{3} of distilled water. A table of results is given for the back e.m.f. at different temperatures. A. A. Noyes has previously established that the electric conductivity of solutions increases with temperature, while ionisation decreases, so that this apparent anomally is now connected with a new factor—namely, the decrease in back e.m.f. of polarisation with temperature. The first set of experiments were made up to 80° C. at constant pressure, and thence to 190° under the tension of water-vapour only. In order to prove that pressure played no part, experiments were made under reduced pressure at the ordinary temperature, whereby no appreciable change was detectable. The general results obtained were that the back e.m.f. of a solution of sulphuric acid diminishes at first with temperature, being sensibly proportional to the inverse of the absolute temperature, but from 60° to 120° much more rapidly. Above 120° there is practically no further variation. This change may be ascribed to a difference in the mode of ionisation, which at first is H^+ and HSO_4^-, and afterwards $2H^+$ and SO_4^{--}.

H. H. Ho.

1264. *Anodic Oxygen Evolution below the Reversible Oxygen Potential.* **G. Grube** and **B. Dulk.** (Zeits. Elektrochem. 24. pp. 237–248, Aug. 1, 1918.)—It is generally assumed that the supertension of the platinised Pt anode when evolving oxygen is due to the fact that the Pt is not unattackable, but that the electrolytic oxygen forms with the metal of the surface an oxide PtO_x which is subsequently decomposed. The transformation $2O \longrightarrow O_2$ would then be sluggish and proceed at a slower rate than the oxidation of the platinum and decomposition of the oxide. The PtO_x would determine the potential of the electrode; the oxide is probably not present in a free state but rather as a solid solution or in adsorption-equilibrium (Foerster). The authors make potential measurements in cells containing 2N-sulphuric acid (also N-caustic soda) with direct current on which alternating current is superposed. The alternating current has a depolarising effect due to the reduction of platinum oxide by the kathodic component. When the a.c. intensity is gradually raised, the anode (oxygen) potential falls below the potential of the reversible oxygen formation. The potential curve consists of three branches, for which the potentials range respectively from 2·0 down to 1·5 volts, from 1·5 to 1·28, and from 1·28 to 1·0 volt. To explain the phenomena it is suggested that, above its equilibrium potential of 1·28 volts, the electromotive activity of oxygen is due to two different oxides. For the medium range 1·5 to 1·28 the oxide is PtO_3; for the upper range it must be a higher oxide, the x being unknown so far. The evolution of oxygen below 1·28 is due to the reaction $H_2O_2 + O \longrightarrow H_2O + O_2$, the hydrogen peroxide being formed at the anode by the alternating current.

H. B.